RECREATIONAL BOAT SAFETY COLLISION RESEARCH-PHASE II VOLUME II - COLLISION ACCIDENT INVESTIGATIONS - 1975

Wyle Laboratories
Huntsville, AL

Jul 76

REPORT NO. CG-D-129-76

RECREATIONAL BOAT SAFETY
COLLISION RESEARCH-PHASE II

VOLUME II - COLLISION ACCIDENT INVESTIGATIONS - 1975

JULY 1976

FINAL REPORT

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

OFFICE OF RESEARCH AND DEVELOPMENT

WASHINGTON, D.C. 20590

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CG-D-129-76		

4. Title and Subtitle	5. Report Date
RECREATIONAL BOAT SAFETY COLLISION RESEARCH — PHASE II Volume II — Collision Accident Investigations - 1975	July 1976
	6. Performing Organization Code
7. Author(s): R. MacNeill, S. Cohen	8. Performing Organization Report No. MSR 76-39
9. Performing Organization Name and Address Wyle Laboratories P.O. Box 1008 Huntsville, Alabama 35807	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT-CG-40672-A (T.O. 12)
12. Sponsoring Agency Name and Address U.S. Department of Transportation United States Coast Guard Office of Research and Development Washington, D.C. 20590	13. Type of Report and Period Covered Final Report May, 1975 to May, 1976
	14. Sponsoring Agency Code U. S. Coast Guard (G-DSA)

15. Supplementary Notes
Volume I — Problems Definition; Safety Enhancement Concepts
Volume II — Collision Accident Investigations - 1975

16. Abstract

The 1975 collision research report has been divided into two volumes for convenience. Volume I includes the results of the three Visual Alertness Stressor Tests (VAST) and the results of the cause and stressor identification effort. Volume II is a compilation of the ten individual in-depth reports of the ten collisions that were investigated by Wyle during 1975. Some analyses of causes are presented as is an analysis of the differences between the collision data received from the WATS accident reporting system (the source of accident information leading to accident investigations) and the collision data in CG-357-1975 (representative of all collisions).

The results of the research effort and recommendations for future research are found in Volume I.

17. Key Words	18. Distribution Statement
Collisions, Boating Collisions, Collision Research, Accidents	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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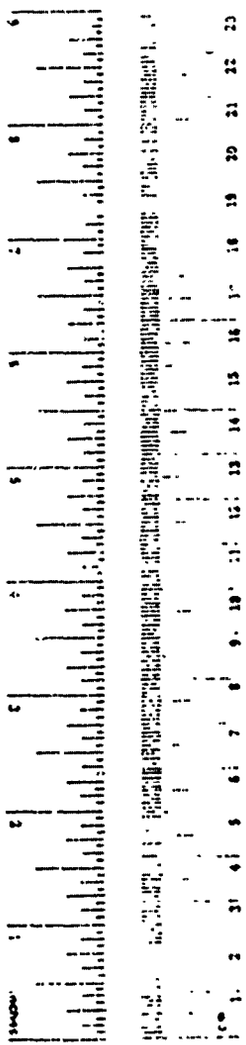
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

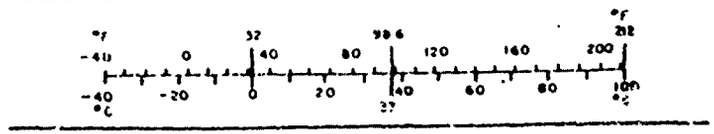
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly)



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

In 1974 research was initiated into the pleasure boat collision problem. The main effort involved cause identification. Coast Guard collision accident statistics were studied, probable causes were identified, and a research effort was started in the area of boat operator stressors as they affect his performance[1].

The Coast Guard also initiated a program of in-depth collision accident investigations, wherein, trained investigators from Wyle Laboratories were sent to investigate collisions as soon as possible after they occurred. By talking with the victims and witnesses, by examining the boat(s), and by studying the collision area, the investigators were able to recreate the circumstances leading up to the collision and the collision itself in greater detail than would have been possible if: 1) the collision had been investigated some time after the occurrence, or 2) the details of the collision had been gleaned from BARs[2]. Wyle investigators were able to not only investigate collisions involving deaths but also investigate non-fatal collisions and collisions occurring in waters under state jurisdiction. Six collisions were investigated in-depth in 1974.

The collision research effort has continued through 1975 and has dealt with boat operator performance degradation experiments, based on the hypothesis that a performance degradation may be expected when certain stressors are present. The cause identification phase has been completed and ten (10) additional collisions have been investigated in-depth.

The Phase II Collision Research Report has been divided into two volumes for convenience. Volume I includes the results of the three Visual Alertness Stressor Tests (VAST) and the results of the cause and stressor identification effort[3].

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[1] MacNeill, R., et al. Recreational Boat Safety Collision Research - Phase I. Vol. I, Problems Definition. Final Report for the U.S. Coast Guard by Wyle Laboratories, 1975. NTIS No. AD A015 819.

[2] MacNeill, R., Recreational Boat Safety Collision Research - Phase I. Volume II, Collision Accident Investigations for 1974 Season. Final Report for the U.S. Coast Guard by Wyle Laboratories, 1975. NTIS No. AD A015 820.

[3] MacNeill, R., et al. Recreational Boat Safety Collision Research - Phase II. Volume I, Problems Definition; Safety Enhancement Concepts. Report for the U.S. Coast Guard by Wyle Laboratories, 1976.

Volume II summarizes the information obtained from the 1975 Collision Accident Investigation Program. Statistics from all reported collisions are examined and details from the 10 collisions that were investigated are discussed. A more complete cause and stressor analysis of the collision investigations is included in Volume I along with an analysis of the value of alternative data sources for determining stressors, causes, activity, etc.

2.0 BACKGROUND

In order to conduct the collision investigations in a timely manner, it was necessary that Wyle be informed quickly of as many accidents as possible. The present Boating Accident Report System is unsatisfactory for this effort, due to the length of time required for most reports to reach Coast Guard Headquarters, and the tendency for persons not to report non-fatal accidents.

A WATS line has been used for the past three years to accumulate information quickly on accidents as they occur. Coast Guard units are requested to telephone accidents to the WATS for rapid accident reporting. This past year, the line was transferred from Coast Guard Headquarters (in Washington) to Wyle Laboratories in Huntsville, Alabama. Wyle, under contract to the Coast Guard to perform many types of accident research, was able to obtain first hand timely reports of accidents.

Details of the WATS reporting system and the data collected on all accidents have been documented in the WATS report[4].

[4] Shikoh, A. and Bowman, J., WATS Accidents Reported in 1975, A Summary of the Accident Alert Reports, Report for U.S. Coast Guard by Wyle Laboratories, 1976.

3.0 THE WATS DATA

Seven hundred and ninety-six accidents were reported over the 1975 WATS reporting system. Two hundred and twenty-six of those accidents, or 28%, were collisions. Thirty-four percent of the boats involved in all WATS reported accidents were involved in collisions. Collisions are defined as those boating accidents where two or more boats hit each other, one boat hits a fixed object (above or below the water surface), one boat hits a floating object (above or below the water surface), and groundings.

Table 1 compares some statistics from the 1975 WATS reports with 1975 CG-357 statistics. Comparison of these statistics will show any biases in the WATS reporting vis-a-vis CG-357 statistics.

Death and injury rates show significant differences between the WATS data and CG-357 statistics. This is due to the manner in which data for these two sources are collected. The WATS reports are called in directly from Coast Guard stations and concern accidents which have just taken place. CG-357 statistics are based on a wider variety of reports, including Boating Accident Reports (BARs) sent in by boating accident victims. Consequently, CG-357 statistics include more accidents of a less serious nature. Since the Coast Guard is required to investigate fatal accidents, the data reported by it over the WATS system should be expected to be more heavily weighted toward fatalities than is CG-357 data. Conversely, as some insurance companies are now sending BARs with insurance claim forms, CG-357 data now reflects more accidents involving injuries than in the past, accidents not reported to the Coast Guard at the time of occurrence. Consequently, CG-357 statistics indicate a higher injury rate than do WATS statistics.

In general, the relative frequencies of boat lengths in the WATS and CG-357 statistics are about the same. WATS reports contain relatively fewer smaller boat collisions and relatively more larger boat collisions. This is understandable in light of the fact that WATS reports come from Coast Guard stations which are generally located along coast lines. The data pattern for collisions by water type strikingly demonstrates this explanation. Finally, the relative frequencies of propulsion systems in WATS and CG-357 statistics are close, the differencies again being attributable to the location of Coast Guard stations.

TABLE 1. COMPARISONS OF 1975 WATS COLLISION STATISTICS AND 1975 CG-357 STATISTICS

	WATS	CG-357
Deaths per collision	.12	.05
Injuries per collision	.11	.34
Boat length: percent of boats in each class		
< 16 ft (4.9 m)	12	21
16 ft (4.9 m) to < 26 ft (7.9 m)	52	55
26 ft (7.9 m) to < 40 ft (12.2 m)	28	18
40 ft (12.2 m) and over	8	5
Water type: percent of collision-involved boats in each type		
Oceans or Gulf of Mexico	12	5
Great Lakes	12	3
Tidal waters	50	28
Non-tidal waters	26	63
Propulsion system: percent of collision-involved boats with each type		
Inboard	35	31
Outboard	39	46
Inboard/Outdrive	18	16
Other	9	8

We now turn to specific category analyses of 1975 WATS reported collisions. Accident statistics were examined by each of the following classifications:

- time of day,
- boat length,
- water type,
- propulsion system,
- boat type,
- hull type,
- hull material,
- day of week,
- month of year, and
- number of people on board.

For each of the above, three types of WATS reported data was analyzed:

(a) relative frequency (percent) of collision-involved boats,

(b) percentage of accident-involved boats which were collision-involved, and

(c) percent of collision-involved boats which had fatalities.

Type (a) data was obtained for each classification by dividing the number of collision-involved boats in each category by the total number of collision-involved boats. Type (b) data was obtained by dividing the number of collision-involved boats in each category by the total number of accident-involved boats in that category. This data was developed to give a rough comparison of collisions to exposure, using the number of all accidents as the exposure guide. Type (c) data was obtained by dividing the number of collision-involved boats for which at least one fatality occurred by the total number of collision-involved boats in that category. Type (c) data gives a guide to the seriousness of collisions. All calculations were based on known data, the unknown data being omitted. This is equivalent to the assumption that the known data reflects the unknown data. Where less than five cases occurred in a category, no conclusions were drawn, the category being considered as having insufficient data. The raw data upon which the analyses were based may be found in the WATS report[4].

Rather than discuss the details of each categorization scheme, we shall limit ourselves to a discussion of the more striking results obtained.

Two peaks in collision frequency as a function of the time of day were found. One peak occurs in the early afternoon, centered at about 1400 hrs. The second peak occurs at night, centered at about 2300 hrs. When collision frequencies are compared with all accident frequencies, only an evening-nighttime peak is found. The peak rises steeply at 1900 hrs and then falls off gradually. Since the afternoon peak disappears when collisions are compared with all accidents, its existence is probably due to there being more boats in use at that time, which results in more accidents of all types occurring in the early afternoon.

However, the peak in evening and nighttime collisions cannot be explained in this manner as the number of these collisions is still large even when compared with all accident types. Thus, it appears that these collisions deserve closer study, and this problem is addressed in Volume I of this report [3].

Collisions categorized by water type were analyzed. The percentage of collisions was highest in tidal waters in the 1975 WATS reports. When compared with all accident types, however, non-tidal waters and the Great Lakes had the highest relative frequency of collisions. Also, non-tidal waters led the other water types by far in the percent of fatal collisions, over 40% of the involved boats having at least one fatality.

WATS reported collisions involved twice as many boats in the 16 ft (4.9 m) to less than 26 ft (7.9 m) class than in the length class with the next greatest frequency. Yet when collisions are compared to all accident types, boats in this length class do not stand out. This probably indicates that the high relative collision frequency for boats in this class is due to a relatively larger number of these boats in use (at least in the vicinity of Coast Guard stations). It was found that as boat length increases, the ratio of collisions to all accidents increases, indicating either that larger boats are more likely to be involved in collisions than are smaller boats, or that they are less likely to be involved in other types of accidents. Finally, it was found that the percent of collision-involved boats which had fatalities decreased as length increased, indicating that, once in a collision, larger boats are safer than smaller ones.

Roughly speaking, collision rate is proportional to boat size and death rate in inversely proportional to boat size. The first statement may be due to the visibility problems defined in Volume I. The second statement is easy to understand especially in two boat accidents; i.e., the casualty rate in the smaller of the two boats would be higher. Analysis of collisions by boat type supports these findings in that the cabin motorboat collision rate is higher than the open motorboat collision rate when they are compared to all accidents, but the death rate for cabin motorboats in a collision is lower.

The categorization of collisions by propulsion system indicated no striking results, except perhaps for the small percentage of collisions which are fatal in inboard boats, a result which should be expected in light of the previous finding that the percentage of collisions which are fatal decreases with increased boat length, and the fact that inboard boats tend to be the larger boats. The results of classification by hull type were not particularly surprising. A rather high percent of collisions which were fatal in cathedral hull boats was found. This may be the result of many boats with this hull type being bowriders. Categorization of collisions by hull material also showed no particularly striking results.

As would be expected, more collisions occur on Saturday and Sunday than on weekdays. It was found, however, that the percentage of collisions which involved fatalities was greater on every weekday except Wednesday than on Saturday or Sunday. Perhaps boaters are more careful on weekends when waterways are more crowded. Another possibility might be that weekday boaters may be more fatigued or pressured by time than are weekend boaters.

No unexpected results were found in the examination of collision data by month except April showed a fatal collision to collision ratio almost twice that of any other month. Perhaps this is the result of many inexperienced boaters doing their first boating of the year in April when low water temperatures can turn a collision into a fatal accident. Another possibility is that this result is just the result of random sample data fluctuation.

Finally, classification by number of people on board showed no unexpected results other than what could be explained by random variation.

4.0 CAUSE SUMMARY — 1975 IN-DEPTH INVESTIGATIONS

Each of the ten collisions investigated in-depth was coded for cause by three coders, using the collision coding tree shown in Figure 1 and the stressor/human engineering questionnaire shown in Figure 2. Data for each boat involved in the collision were coded, as opposed to the data for the collision itself, so the number of data points becomes fifteen rather than ten because five of the collisions involved two boats.

RESULTS OF 1975 IN-DEPTH INVESTIGATIONS

	Cases	% of Total
The boat was underway	14	93
The operator tried to take an avoidance action	5	33
- he made an improper response	1	7
- he didn't see the other boat in time	4	27
The operator did not try to take an avoidance action	9	60
- he saw the other boat but didn't have time to try to avoid the collision	1	7
- he didn't see the other boat:		
- because he wasn't looking	3	20
- because his vision was obscured	3	20
- because the other boat/object wasn't visible	2	13
The boat wasn't underway	1	7
- The operator didn't see other boat because he wasn't looking	1	7

Two important points may be drawn from the data:

1. Visibility oriented problems were identified as causing the collision in 94 % of the cases, broken down as follows:
   - he didn't see boat/object in time to avoid it:
     - but tried to 27%
     - didn't try 7%

- he didn't see boat/object at all because:

he wasn't looking	27%
his vision was obscured	20%
it wasn't visible	13%

2. He didn't try to avoid boat/object in almost 2/3 of the cases.

4.1 Stressors

Human factors and/or stressor problems of some sort were identified in every collision investigated. Shock/vibration, noise, and glare were identified as being present in either unusually high quantities or for prolonged periods of time in 60% of the cases each. Examples of situations where coders agreed that a stressor "was present" are:

- The boat was headed SE for some period of time during early morning hours (of SW in the afternoon).
- The boat was a "hot rod" type without mufflers and had been running at high speeds for some periods of time (noise, wind (if no wind shield), and vibration).
- The operator had been drinking alcoholic beverages.

At least one of the three were present in eight of the ten collisions investigated. Seven of the fifteen operators were definitely sober. Five of them had been drinking. None were identified as being legally drunk.

A human engineering problem in the control station was found in almost half of the boats involved and seven of the ten collisions investigated.

A detailed analysis of the stressor problem may be found in Volume II.; however, the following table is presented on the stressors identified as being present in the ten in-depth investigations.

NOTE:

The sum of yes and no percents sometimes total less than 100% because of unknowns	Boat Type						All Three Types N = 15	
	Open Motorboat N = 9		Cabin Motorboat N = 3		Sail N = 3			
Stressor	Yes	No	Yes	No	Yes	No	Yes	No
Operator Was Drinking	44%	33%	33%	33%	0	100%	33%	47%
Shock/Vibration	56%	22%	100%	0	33%	67%	60%	27%
Noise	56%	33%	100%	0	33%	67%	60%	33%
Glare	56%	11%	100%	0	33%	33%	60%	13%
Human Eng. Problem	44%	11%	33%	33%	67%	0	47%	13%
ALL STRESSORS (Average of Above)	51%	22%	73%	13%	33%	53%	52%	27%

The percentages were derived by dividing the number of yes and no answers on the questionnaire by the total number of boats.

The number of boats in each category was so small that statistical analyses were not performed. However, we can note that stressor problems were present in fourteen of the fifteen cells, and within those fourteen cells stressors were present in a minimum of 1/3 of the cases, a maximum of 100% of the cases and an average of 52% of the cases. Stressors were not identified as being present in 27% of the cases.

When we combine the results of coding the collisions through the coding tree with the results of the stressor questions, we find that:

1. Visibility problems were involved in 94% of the collisions.
2. Stressors such as alcohol, excessive amounts of shock, vibration, noise, and glare, and human engineering problems in the control station were present in more than half of the cases.

The visibility problem and stressor problem are discussed in depth in Volume I.

4.2 Causes and Stressors — Twenty-Eight Telephone Interviews

As part of the screening process, Wyle accident investigators generally call victims of several collisions before deciding on one to be investigated in-depth. Therefore, more information is known about those "in-depth rejects" than the rest of the collisions that have been called in. Twenty-eight such accidents exist from the 1975 WATS collisions. Causes were identified and the stressor questionnaire was completed on each of the twenty-eight collisions in an effort to determine how much of the stressor and cause data could be collected from telephone interviews.

The cause data looked similar to that of the in-depth collisions; however, the stressor data included 93% unknowns. The data was compiled from reports of telephone conversations with accident victims, Coast Guard personnel, police, witnesses, etc. The purpose of the telephone calls was to ask questions to get enough information to determine if we wanted to investigate the accident in-depth.

The conversations were terminated at the point when the investigator made his decision not to investigate. In many cases that was early in the conversation when he found that: 1) the witness didn't want to cooperate, 2) the boat wasn't available, 3) a law suit was pending, 4) etc. For these reasons, many conversations did not last long enough to obtain stressor data. This doesn't mean that stressor information cannot be obtained through telephone interview techniques. It means that the purpose of the original telephone calls were to set up interviews, not to get stressor information.

In the future, a telephone based stressor study could be performed and could have a high probability of success if it were designed properly. Wyle has the mechanisms available to perform this sort of study. The names and telephone numbers of victims are available from the WATS accident reporting system, and the WATS computerized data system has stressor data space available.

Part of the Phase II Collision Research includes an effort to determine if stressors can be identified in BARs and MIO reports of collisions. Results show that the percent of unknown answers to the stressor questions is about ninety percent.

CAUSE DATA COMPARISON

	% of Total	
	10 In-Depth	28 Calls
This boat underway	93	92
This operator tried to take avoidance action	31	33
This operator did not try to avoid collision	60	46
This boat wasn't underway	7	8

STRESSOR DATA COMPARISON

	% Of Total			
	10 In-Depth		28 Calls	
	Yes	Unknown	Yes	Unknown
This operator was sober	47	27	0	92
This operator had been drinking	33	20	8	92
This operator was legally drunk	0	47	3	97
He was subjected to a high amount of:				
- shock/vibration	60	7	3	97
- noise	60	7	8	90
- glare	60	27	10	90
Human Engineering problem with control station	47	40	8	90
TOTALS	43	25	6	93

No analysis of causes or stressors will be made here since it would be a duplication of material in Volume I[3]. Again, for a complete analysis of collision causes and fatigue producing stressors present prior to those collisions, refer to Volume I.

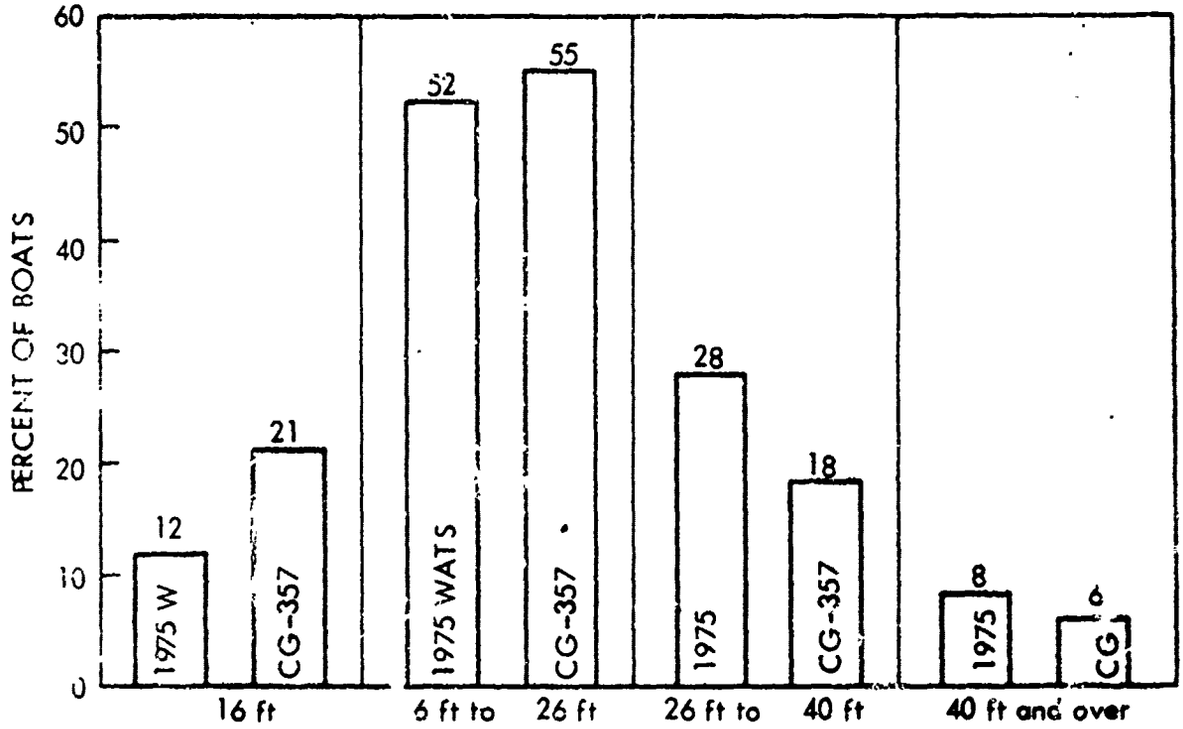

FIGURE 1. PERCENT OF COLLISIONS AS A FUNCTION OF BOAT LENGTH

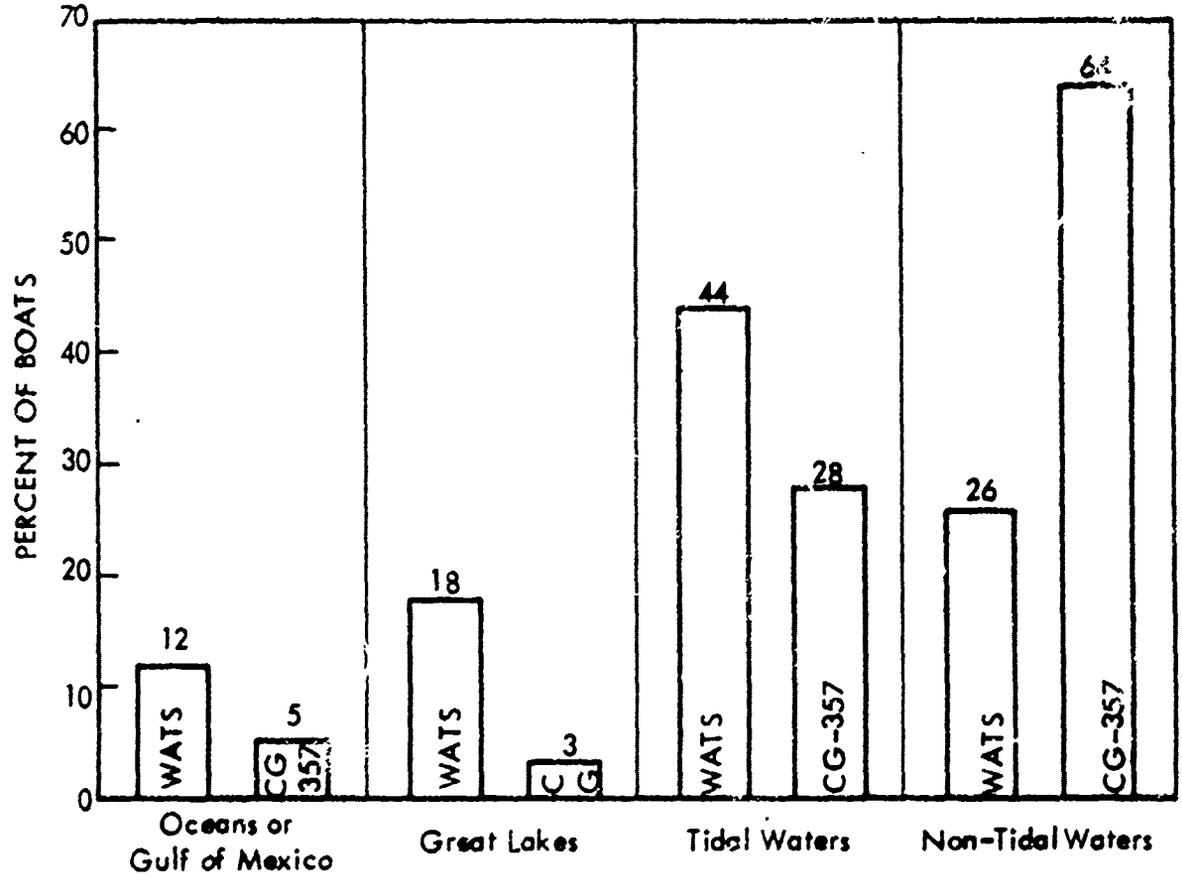

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FIGURE 2. PERCENT OF COLLISIONS AS A FUNCTION OF WATER TYPE

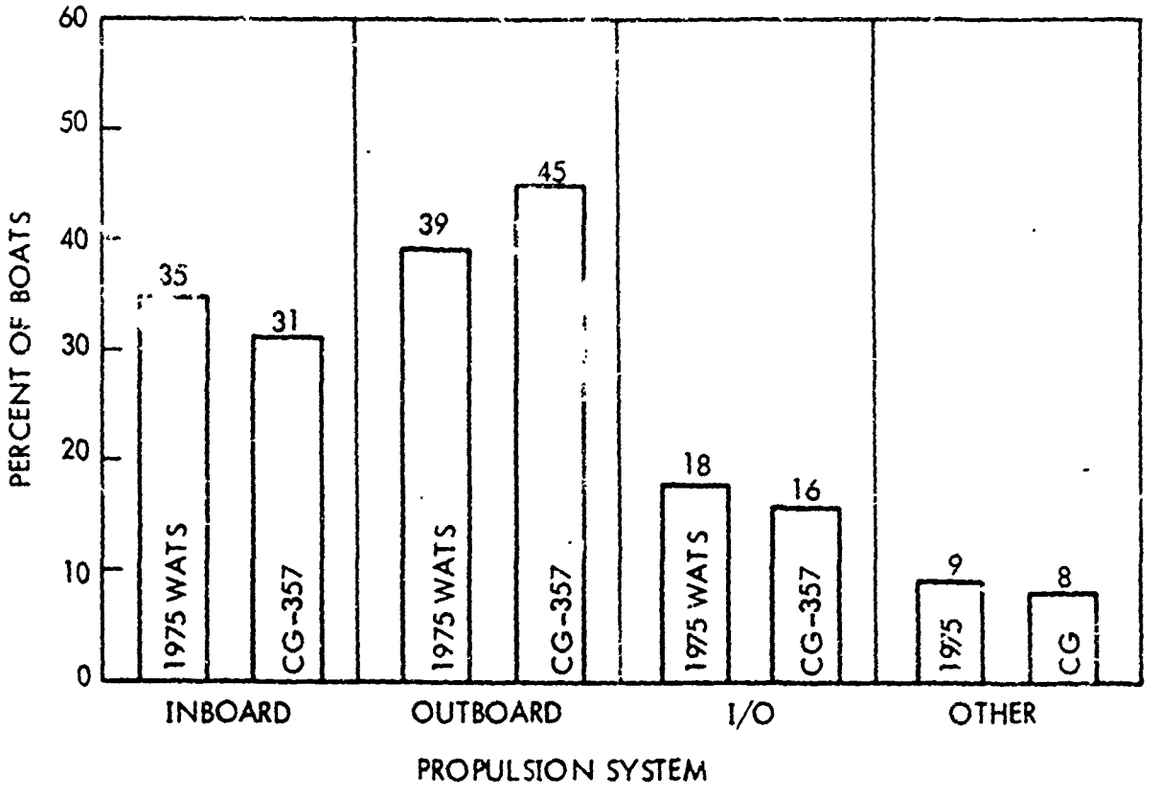


FIGURE 3. PERCENT OF COLLISIONS AS A FUNCTION OF PROPULSION SYSTEMS

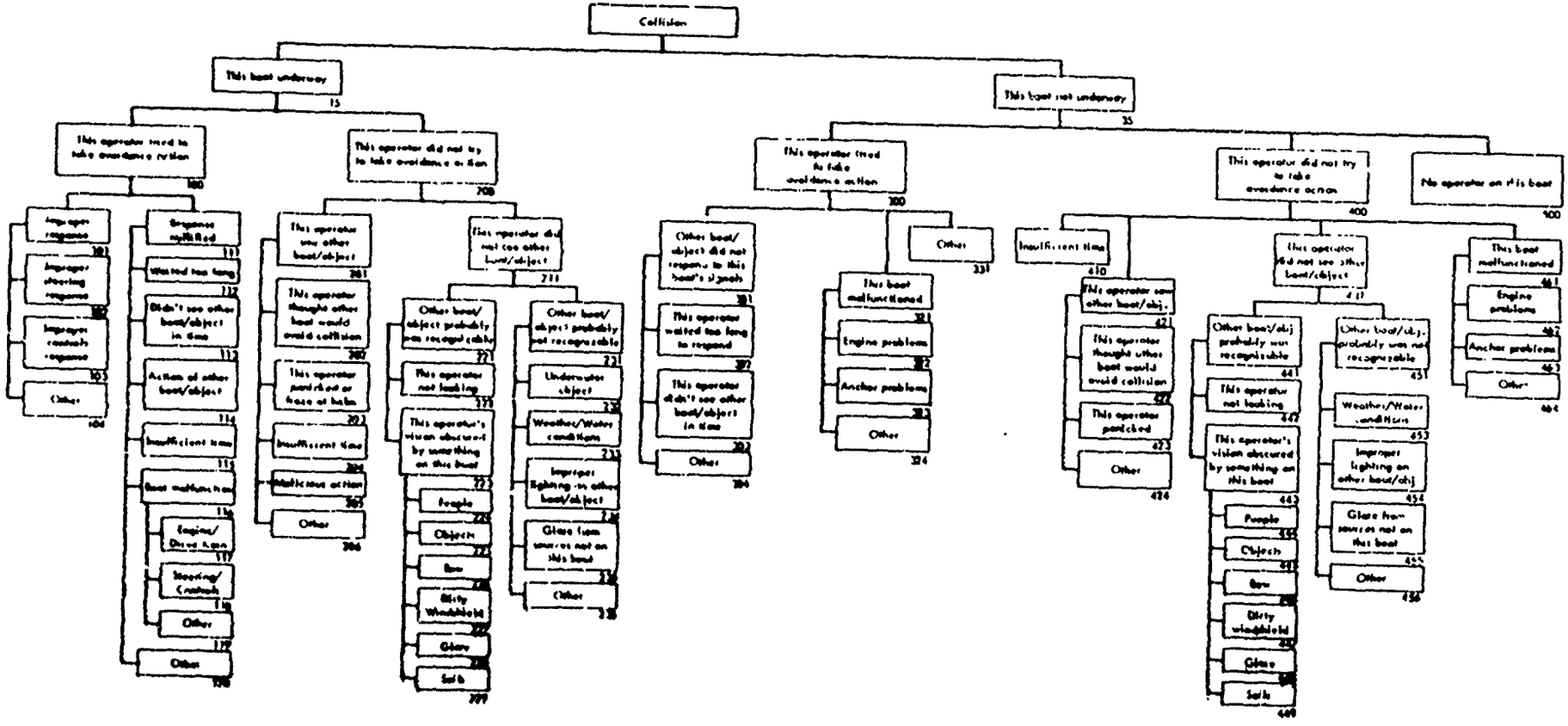


FIGURE 1. COLLISION CAUSE CODING TREE

		Yes	No	Unknown	N/A
1.	How long had this operator been on the water? _____ Hrs				
2.	This operator was: Sober				
3.	Had been drinking				
4.	Was legally drunk				
5.	Prior to the collision, this operator was subjected to a high amount or prolonged exposure to: Shock/Vibration				
6.	Noise				
7.	Glare				
8.	Human engineering problem with control station or controls				
9.	Just prior to the collision, this operator: Was in proper position				
10.	Was looking away				
11.	Was at the helm				
12.	Made a navigational error				
13.	Was operating in a reckless or malicious manner				
14.	Signalled other vessel				
15.	If this collision occurred at night, were the light legal on this boat?				
16.	Was this boat priviledged?				
17.	Before the collision, this boat was: Proceeding too fast for conditions				
18.	Out of control				
19.	In hazardous waters				

FIGURE 2. STRESSOR/HUMAN ENGINEERING QUESTIONNAIRE

5.0 IN-DEPTH INVESTIGATIONS

5.1 Collision Summaries

Collision 1 — Five people picnicked, waterskiied, and drank alcoholic beverages on the bank of a river for most of the afternoon. It was dark when they decided to go home. Just after leaving the picnic site on their way to the launch ramp, two of the three boats collided. Two people were thrown into the water; one died.

Collision 2 — A runabout hit a bridge abutment at night. The lone occupant was standing at the helm as he approached the bridge. When a large cabin cruiser appeared to block the entire opening, the driver made a sharp right hand turn. The boat swerved, he lost his balance fell to his knees, and was knocked unconscious when the boat hit the bridge.

Collision 3 — Just before dawn, two men were going down a river in a runabout. They hit an unlighted bridge abutment. One man was seriously injured.

Collision 4 — A family was on their way home from an evening cruise when their 31 ft (9.4 m) cruiser ran up onto a lighted breakwater. No one was injured.

Collision 5 — Two sailboats were sailing on opposite tacks on a converging course. Neither operator saw the other boat because the sails obscured their vision. The boats collided.

Collision 6 — A 23 ft (7 m) boat ran up onto a lighted breakwall late at night. The operator made a navigational error while attempting to enter a harbor. No one was injured.

Collision 7 — Just before dawn, a 97 ft (29.7 m) ketch operating under motor alone went aground on a sandbar near a small inlet. Strong current and wave action caused the boat to break up. All seven persons aboard the boat were lifted to safety by a Coast Guard helicopter.

Collision 8 — Two small boats were travelling in opposite directions on a narrow winding creek. They sped around a sharp blind corner and hit each other. No one was injured.

Collision 9 — A lone person in a runabout was pulling a skier and was turned, looking aft. He hit a johnboat. The johnboat operator was thrown overboard, but managed to swim to his circling boat and stop the engine.

Collision 10 — An 18 ft (5.5 m) runabout was anchored in a tidal bay. The wind picked up and caused the water to become quite choppy. A 28 ft (8.5 m) cabin cruiser ran over the anchored boat. No one was seriously injured.

5.2 In-Depth Investigation Reports

ACCIDENT INVESTIGATION REPORT

Date of Investigation: 6 June 1975

Date of Accident: 27 May 1975

Investigation: Collision No. 75-01

SUMMARY — WYLE ACCIDENT NO. 75-166

The accident reported herein involved a 16 ft runabout powered by two 135 horsepower outboard motors and a 7 ft water scooter type pleasure vehicle powered by a 30 horsepower outboard motor. The type of accident was a collision, resulting in the death of one of the two people aboard the water scooter. During the afternoon of May 27, 1975, five adults (3 males and 2 females) gathered on a sandy river beach area for a picnic and pleasure boat outing. The area was located approximately 1/2 mile downstream from a public launch ramp where the involved boats were launched. The party continued the beach/water activity until approximately 8:15 p.m. During the outing, 3/4 of a "fifth" of bourbon was consumed by three of the people (two people were non-drinkers).

At approximately 8:15 p.m., a male and a female boarded a 15 ft runabout (boat not involved in accident) and went to the launch ramp. At approximately 8:30 p.m., the remaining three people prepared to start back to the launch ramp. A male and the remaining female boarded the water scooter with the male seated in the operator's position. The final person (male owner of the involved runabout) boarded his boat. The water scooter got underway first and

started toward the launch ramp. The runabout got underway shortly thereafter and started back to the launch ramp. At approximately 8:35 p.m., the runabout overtook the water scooter and a collision occurred. The water scooter was not equipped with running lights.

The operator of the water scooter and passenger were thrown off. The owner of the runabout, realizing a collision had occurred, turned around and found the water scooter going around in circles. He located the female passenger floating with an AK-1 PFD. The operator could not be found. The runabout owner took the passenger aboard and returned to the launch ramp for help.

The two persons originally in the party went immediately to the site in the 15 ft runabout but found only the water scooter, still running in circles. They left and returned to the launch ramp.

A bystander (with a portable search light) and the female occupant of the 15 ft runabout returned to the site but found nothing except the water scooter (stopped). The bystander rode the water scooter to the ramp. The body of the operator of the water scooter was recovered by rescue squads at approximately 1:20 p.m., May 28, 1975 (the following day).

1.0 BOAT OCCUPANT DATA

Boat No. 1 — 7 ft Water Scooter

Operator/ Passenger	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instruction	PFD's Worn
Operator	M	30	175	Good	>3 yrs	No	No
Passenger	F	21	147	Poor	Little	No	Yes

Boat No. 2 — 16 ft Runabout

Operator	M	27	180	Good	>5 yrs	No	No

The following is based on several interviews with survivors and with the investigating officer as well as friends of the group who were on the outing:

16 ft Runabout Operator (Male)

Likes fast boats - Fast cars - Motorcycles - Used to be a Green Beret - National Guard member - Doesn't drink - Goes away occasionally by himself - Has job - Boat is racy - Two 135 Mercs on special modified transom - Two bladed bronze cupped props set up for top running (~6' raised transom) power trim - 18 gal. tank - Seldom full because of weight (limits speed).

Water Scooter Operator (Male)

Divorced - Reportedly had "some mental problem" a year ago - Reportedly "drinks a good deal" - Brought the liquor on the trip - Skiis, swims - Had job - Deceased.

Water Scooter Passenger (Female)

Giddy, not too verbal - Appeared very dependent on others for guidance - Overweight, non-drinker - Can't swim over a "few feet" - Skittish of water and boats - Was wearing PFD - Wife of passenger in 15 ft boat below.

15 ft Runabout Operator (Female)

Married - Operated boat by herself (Husband was at work) - "Good friends" with husband of water scooter passenger - Extravertish, coy.

15 ft Runabout Passenger (Male)

Quiet - Husband of water scooter passenger - Quite non-committal about accident - Admitted drinking, but "not heavily."

2.0 ENVIRONMENT

The sky was clear, the wind calm, sunset was near 45 minutes previously - there was no moon. The river was relatively narrow, the air temperature estimated at 77 F and water temperature estimated at 71 F. There were no lights on the shore at the accident site. The water depth was approximately 80 ft.

3.0 NARRATIVE OF ACCIDENT

3.1 Pre-Accident

During the course of the afternoon of May 27, 1975, five adults and three boats gathered at a site approximately one-half mile from a launch ramp, intending an outing and cookout. The three boats and occupants arrived at three different times. Three of the persons involved in the outing arrived at the launch ramp at approximately 3:30 p.m. These people were a man (1) and wife (2) and a second female (3) who owned a 15 ft runabout. The 15 ft runabout was launched and the three people proceeded to a locally popular sand bar along the west bank of the river and prepared to cook (see photograph 1 and Figure 1 for accident area).

The water scooter owner (4) arrived at approximately 5:00 p.m. at the sand bar after the people already present on the sand bar had spent some time sunning and boat riding from the sand bar, including two trips to the launch ramp to check on the arrival of no. (4).

The water scooter was ridden by the four as the cookout proceeded. Also, no. (4) had brought a fifth of bourbon which was to be three-fourths consumed by no. 1, 3, and 4. No. 2 did not drink.

The owner of a 16 ft runabout (5) arrived at approximately 6:30 p.m. Although he knew the others, he was not a planned part of the original crew. He had heard at the ramp that they were there, and came to join them. The next two hours (until about 8:15 p.m.) were spent listening to the tape player in the 16 ft boat, swimming, eating and evidently, drinking. No. 5 reportedly did not drink anything.

At approximately 30 minutes after sundown (official sundown 7:56 p.m.), No. 1 and 3 returned to the launch ramp in the 15 ft boat. They sat in the boat "a few minutes" after which no. 1 went to get the car/trailer to remove the boat from the water. Several other boats/people were at the ramp.

Meanwhile, during this time, no. 2 and 4 had decided to start back. No. 5 had been trying to get one of the motors on his boat started. (One was running o.k.). The plan had been for the 16 ft runabout to escort the water scooter since the water scooter had no running lights and darkness was nearing completion.

3.2 Accident

Gear aboard was as shown in Figure 2 and the weather as noted in Section 2.0

The water scooter with no. 2 sected behind no. 4 (and wearing a PFD) started to the ramp. No. 2 said that they had to stand and lean forward to get on plane. She remembered "looking back and seeing the 16 ft runabout's white light and front lights - both of them." She says she remembers nothing else until back at the ramp.

Back at the ramp, no. 3 was preparing to remove her boat as soon as the trailer was in the water. Suddenly, the 16 ft runabout arrived with no. 5 shouting that no. 4 fell off and he "couldn't find him."

According to the investigating officer and other witnesses, the time was approximately 8:45 p.m. ..."just about good dark." No. 5 had the passenger of the water scooter (2) aboard the 16 ft runabout. He said, "I was just getting on plane and felt a loud thump. At first I though I hit a log and felt the floor for water. Then I realized that I may have hit something else and turned around to find the water scooter going around in tight circles. I saw something in the water and grabbed." He thought it was no. 4. It was the female passenger (no. 2). He pulled no. 2 aboard and searched and called for no. 4, but found nothing. Then he proceeded quickly to the ramp for help. No. 2 had been injured as a result of the collision and was taken to a local hospital by private auto.

3.3 Post Accident

A bystander left (on foot) to get to a telephone and call the Marine Police. The call was received at exactly 9:00 p.m., according to police records. In the meantime, no. 5 in the 16 ft boat led no. 3 and a bystander in the 15 ft boat back to the accident site. The water scooter was still going in counter-clockwise circles of about 15 ft diameter. Calls and quick search did not locate no. 4. No lights (flash or search) were aboard. The two boats returned to the ramp. No. 3 left to call her husband who was at work (actually on picket line - company on strike).

The bystander boarded the 16 ft boat with no. 5 with a portable flashlight and again returned to the scene (time, approximately 9:00 p.m.). The water scooter was found stopped — no sign of no. 4. The bystander boarded the water scooter. He found it in gear - forward, with the throttle advanced (did not remember how far). After finding neutral, he was able to start (pull rope) the outboard after two or three trys. He rode the water scooter back to the ramp at a slow speed, arriving at approximately 9:10 p.m. The Marine Police arrived at approximately 9:15 p.m.

Further search that night revealed nothing. The body of the deceased was recovered at the site in nearly 80 ft of water at 1:20 p.m. the next day (May 28, 1975). The official cause of death was listed as "drowning" by the town's elected coroner (a car salesman).

Interviews with the attending mortician yielded the fact that the deceased had a large lump - hen egg size - on the left side of his face. The area was "considerably swollen." The only other marks found on the body were drag hook marks.

The swelling indicated that he had been struck a sharp blow before he drowned. Length of time to cause the swelling could not be estimated, but the swelling could not occur if he had received the blow after death. No autopsy was performed.

No. 2 had several bruises on her right arm, right side of her face and a "black eye" on the right side as well as bruises on the inside of her left lower leg. She was "treated and released" at the hospital emergency room.

4.0 FACTS FROM BOAT INSPECTION

7' Water Scooter (Hydro Cycle)

The boat was a 1966 model of the type shown in the reproduction of a later brochure (1972). The later version has a throttle hand grip which automatically cuts the throttle to idle if released. The involved boat had no such safety mechanism. Attempts to contact the manufacturer for more details yielded no address or phone number for such a company (Hydro Cycle, 215 E. Alma Street; San Jose, California). The original owner of the water scooter said that the boat had been sold to the deceased without motor or controls. The deceased had obtained an old 1953 Johnson and had installed dual lever controls on the port side in front of the driver - see Hydro Cycle brochure and photograph 2.

The controls and motor had been removed at the time of the investigation, but were examined (see photograph 3). The controls had been sold to a neighbor, the motor stored, and the boat taken by the brother of the deceased to a city dump. It could not be located. (The boat photograph is from a local newspaper.)

The controls were examined after they had been installed on the neighbors boat (photograph 4) and they apparently operated o.k. Further investigation revealed that the control cables were not used in the new installation, and that the push-pull cable for the throttle was broken about 5 inches up the coux covering. Examination of the motor throttle arrangement showed a "push-to-open-throttle" arrangement. This means that (with a broken cable) the throttle could be advanced, but would probably not retard.

The boat hull photographs, and the testimony of the investigating officer and the bystander all indicate that damage was found on the starboard side of the water scooter as shown in the boat damage sketch (Figure 3).

16' Sidewinder Runabout

Examination of the boat showed minor damage on the port bow about 6' aft (see Figure 3). Of considerable interest was the fact that this small runabout was equipped with twin 135 hp Mercury outboards with power trim. The transom had been raised to accommodate the motors. They were each equipped with two bladed bronze cupped props. Twin single lever Mercury controls were used. Otherwise, the boat appeared well kept and in good working order. The only exception was that the starboard running light was inoperable (blown lamp). All steering and engines controls operated properly. However, the controls for the power trims were mounted on a wooden panel, but were not connected to any boat structure. They were simply lying on the deck by the operator's right foot. Apparently, the installation was never completed. The 18 gallon tank was about 1/4 full. The boat was kept stored in a garage at the owner's father's home (see photographs 5-8).

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

The following is based on several interviews with survivors and with the investigating officer as well as friends of the group who were on the outing:

According to interviews and one witness, no. 1, 3 and 4 had consumed 3/4 of a fifth of bourbon in about a two hour period. Evenly distributed, this would mean $3/4 \times \frac{128 \text{ oz}}{5} \div 3$ or

about 6 oz each. This amount of alcohol in that period of time (even with eating) could mean that all were definitely in a blood alcohol content condition which would effect their capabilities, and could be as high as the .10 percent BAC, considered legally drunk in most states.

6.0 PROBABLE CAUSE OF THE ACCIDENT

Operating the water scooter in near darkness without lights is certainly a major cause. The operator of the 16 ft runabout knew that the water scooter was ahead and that his boat was faster, so more care could have been given to lookout for the water scooter. Use of alcohol by no. 4 may have caused him not to look behind or to have reacted improperly (or not at all) even if he did see no. 5 overtaking him. He may have turned into the path of no. 5. Also, since no. 5 was "just getting on plane", his high trim angle may have made his running lights hard (or impossible) to see and make his forward visibility obscure.

7.0 DYNAMICS/ANALYSIS OF ACCIDENT

The following is reconstructed from interviews, examination of the boats' conditions, study of the site and condition of boats and persons involved, and interviews with the police and mortician.

The damage to the boats indicate that the collision occurred on the port side of the runabout and starboard side of the water scooter. The angle of impact was probably nearly head-on for the water scooter into the side of the runabout. Examination of the site (see Figure 1) shows the water scooter had to be heading across the river at an unusual angle; perhaps to get a better view around the bend... maybe to get closer to the outside shore where the water has no shallows.

At the point of impact, the water scooter must have been going at least 20 mph ... "We had to lean forward to get on plane." With two people, the boat was capable of at least 25 mph with the 30 hp outboard at full throttle.

The runabout was probably at a speed of 18-26 mph. He was just getting on plane. The distance from the sand bar where they departed would have given him about 300 ft or so to pick up speed.

The impact velocity was probably quite high (20 - 25 mph) as seen from the damage to the water scooter.

Upon impact, the passenger and operator of the water scooter were thrown to their right, colliding with the side of the runabout . . . bruises to the right side of passenger. Since the collision was on some angle, the water scooter probably rotated (yawed) to the left (stern swung to the right). Both people probably went overboard to the port side of the water scooter. At this point, the runabout was out ahead of the water scooter, two people were in the water, and the water scooter was going in counter-clockwise circles.

From the final condition of the passenger and operator of the water scooter, the passenger avoided contact with the circling boat. But, from the facial damage to the operator (which was on the left - opposite side from the collision), the water scooter apparently ran into him, rendering him either unconscious or nearly so. He must have survived some period after the facial blow in order for the swelling to develop, but it is impossible to say how long he stayed alive. Apparently, he did not stay on the surface long, since he could not be found a very short time later - maybe two to three minutes.

The passenger was definitely saved by the PFD she was wearing. The death may have been prevented if the operator also had worn a PFD.

The broken throttle cable on the water scooter cannot be explained adequately. If it broke before or at the time of the accident, the operator would not have been able to reduce throttle (at least quickly). But, the boat was driven back to the ramp and the person doing so saw no abnormal operation. So, the cable most probably was broken somehow after the accident and before the investigation.

Had the water scooter been equipped with a "dead man" throttle (as later models are), the deceased may have been saved. If the runabout had a spotlight, he may have been able to see the operator in the water and save him, but that is remote.

TIME SEQUENCE

3:30 p.m. - No. 1, 2, and 3 left launch ramp in 15 ft runabout.

3:35 p.m. - No. 1, 2, and 3 arrived at beach area .

3:35-5:00 p.m. -No. 1, 2, and 3 engaged in beach activity and boat riding.

5:00 p.m. - No. 4 arrived at the beach area on the water scooter

5:00-6:30 p.m. -No. 1, 2, 3, and 4 continued beach activity, boat riding, eating, and drinking.

6:30 p.m. - No. 5 arrived at the beach area with the 16 ft runabout.

6:30-8:00 p.m. - Party continued beach activity, boat riding, eating, and drinking.

8:00 p.m. - No. 1 and 3 returned to the launch ramp in the 15 ft runabout.

8:30 p.m. - No. 2 and 4 started back to the launch ramp on the water scooter.

8:31 p.m. - No. 5 started back to the launch ramp in the 16 ft runabout.

8:31-8:32 p.m. - 16 ft runabout collided with water scooter

8:33 p.m. - No. 2 helped aboard the 16 ft runabout

8:33-8:41 p.m. - Occupants of the 16 ft runabout searched and called for no. 4

8:45 p.m. - 16 ft runabout arrived at launch ramp and no. 2 taken to hospital

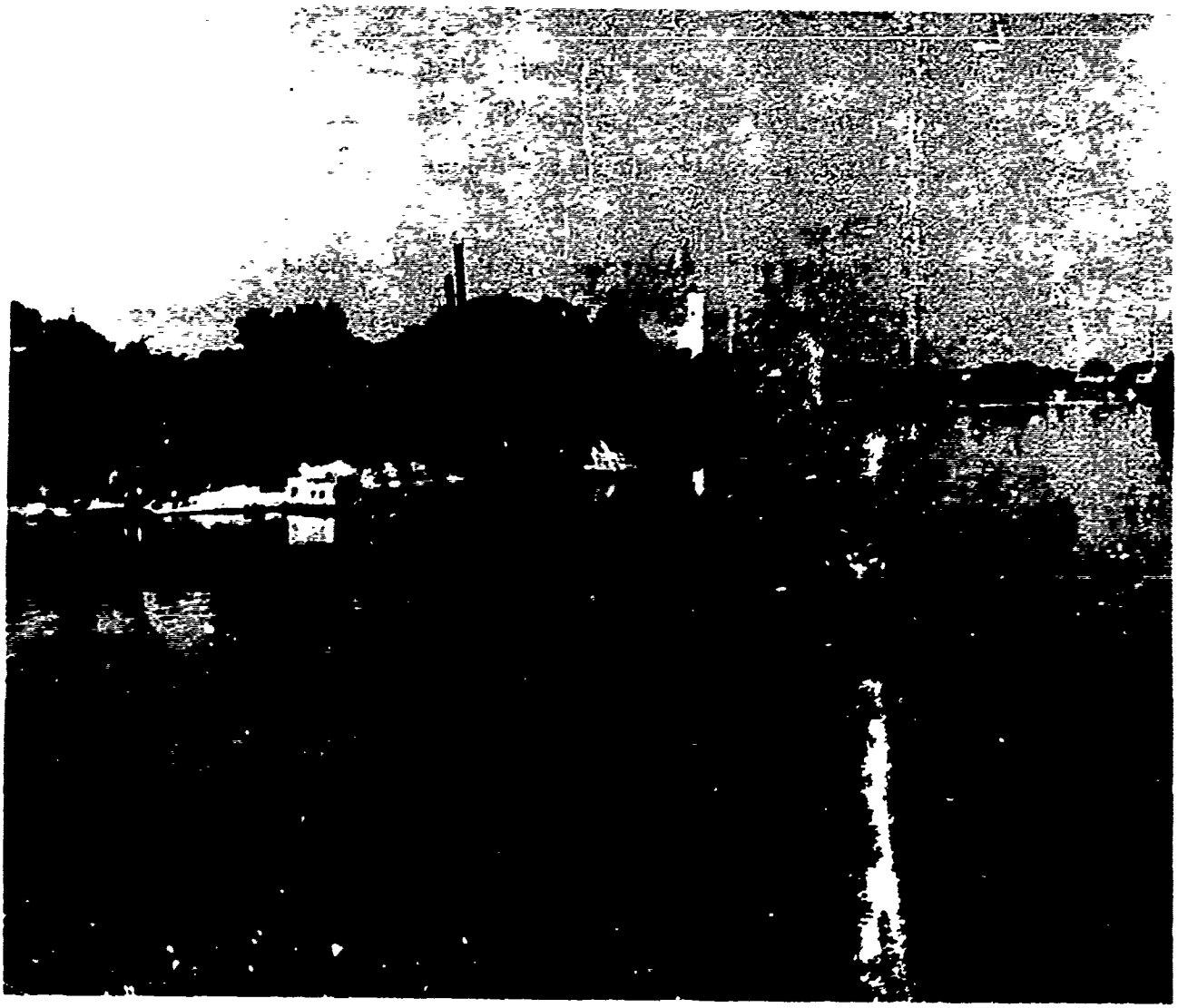
8:45-9:00 p.m. - 16 ft and 15 ft runabout returned to the accident area and searched for no. 4 and returned to launch ramp for search light.

9:00-9:05 p.m. - 16 ft runabout returned to accident site and search was made for no. 4 using a portable flash light. Water scooter found stopped.

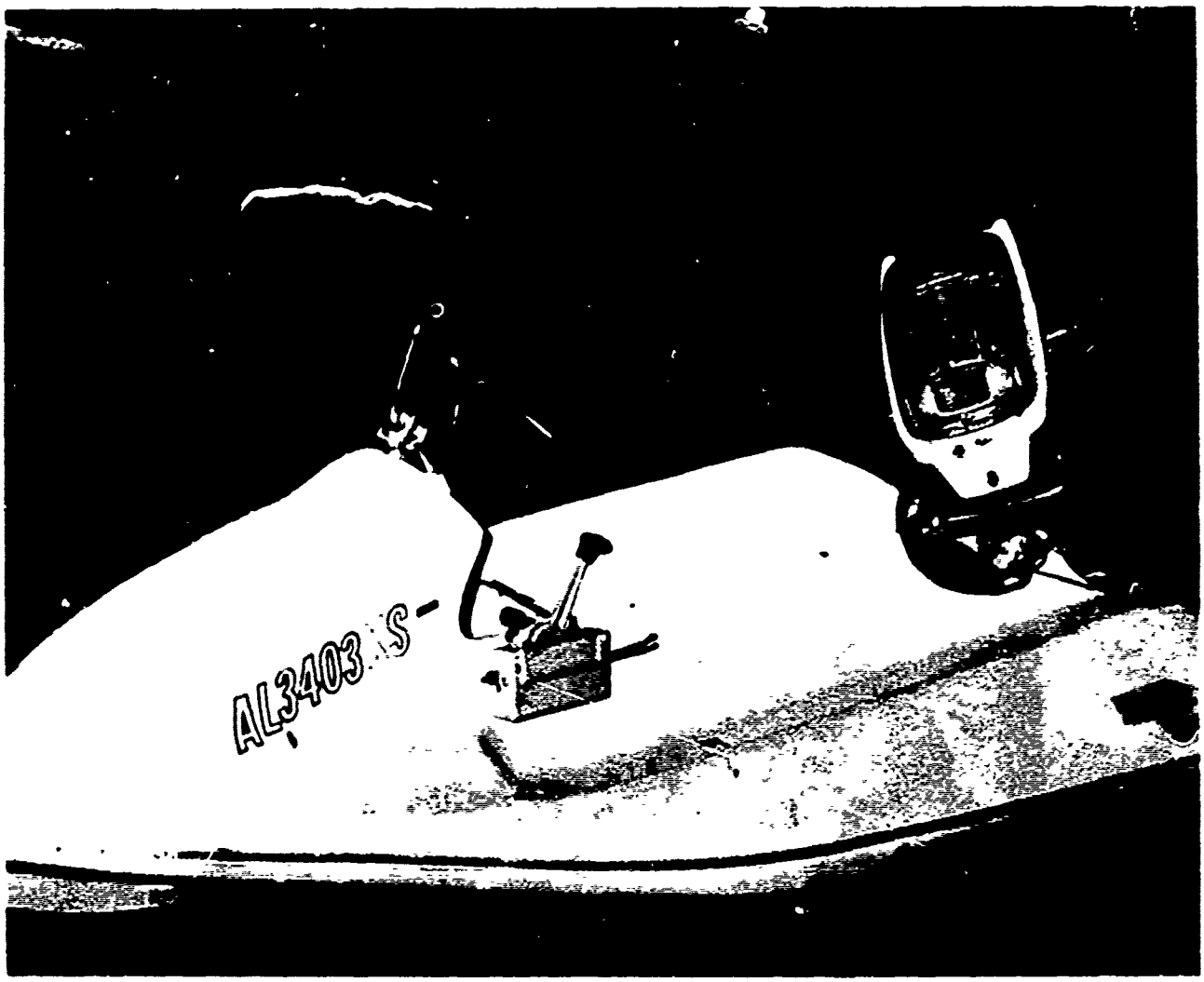
9:10 p.m. - 16 ft runabout and water scooter returned to launch ramp.

9:15 p.m. - Marine police arrived at accident site and started dragging operation for no. 4.

1:20 p.m., May 28 — Body of no. 4 found in 80 ft of water at accident site.

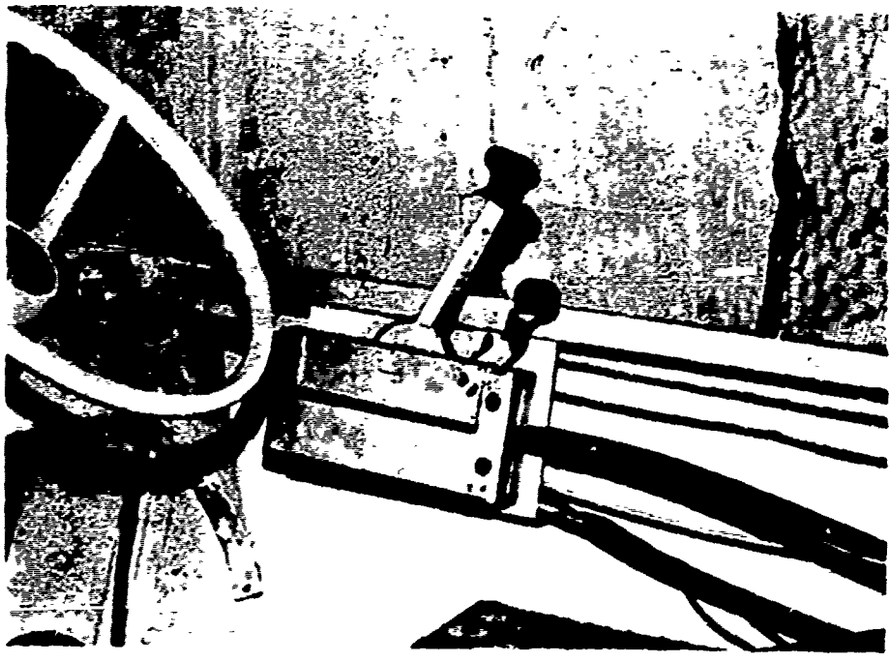


Photograph 1. Accident Scene, May 28, a.m. — Dragging for Deceased



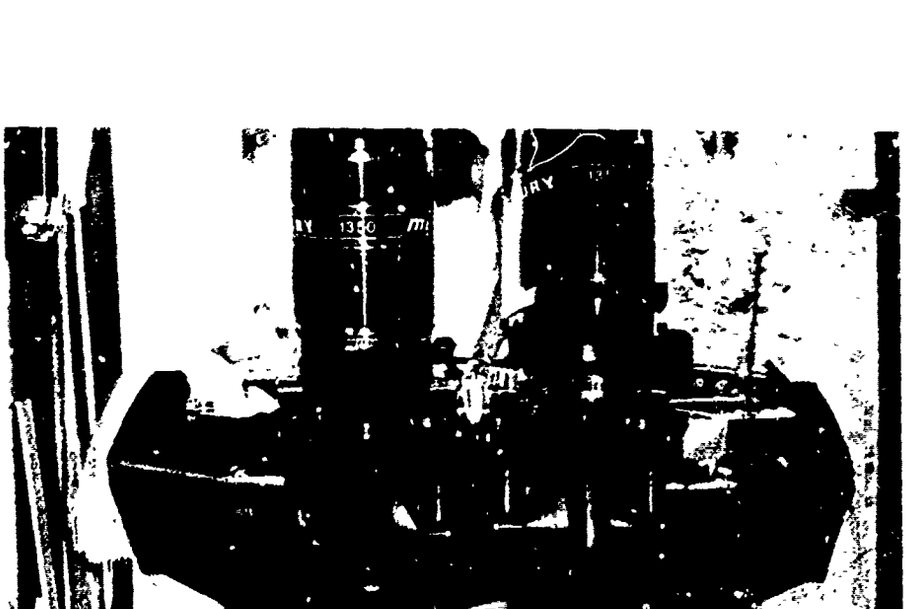
Photograph 2. Water Scooter After Accident No. 166; May 27, 1975

Photograph 3. Water Scooter Motor

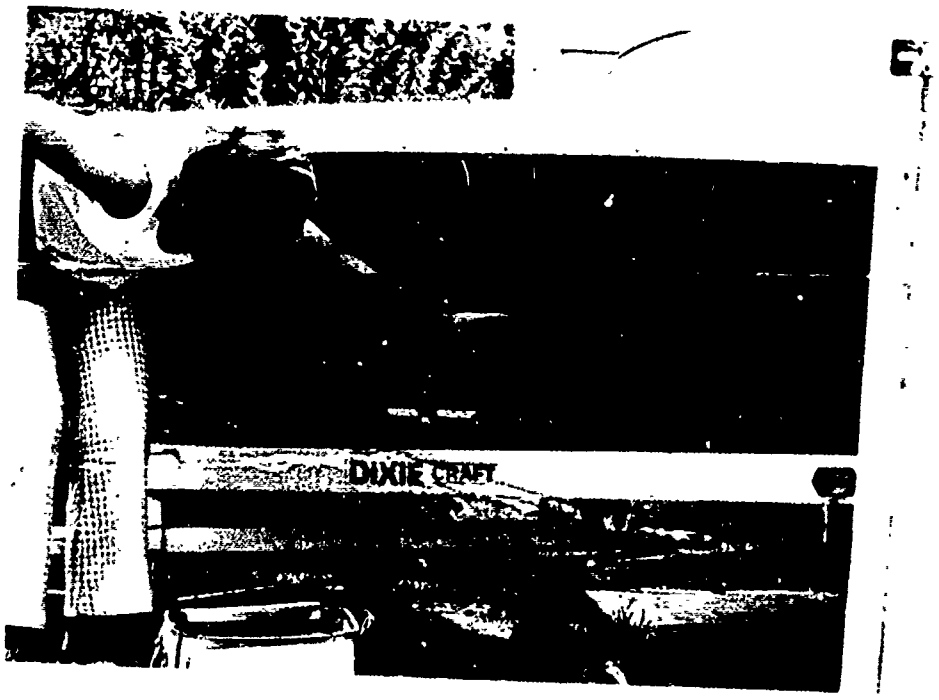


Photograph 4. Water Scooter Shift and Throttle Controls

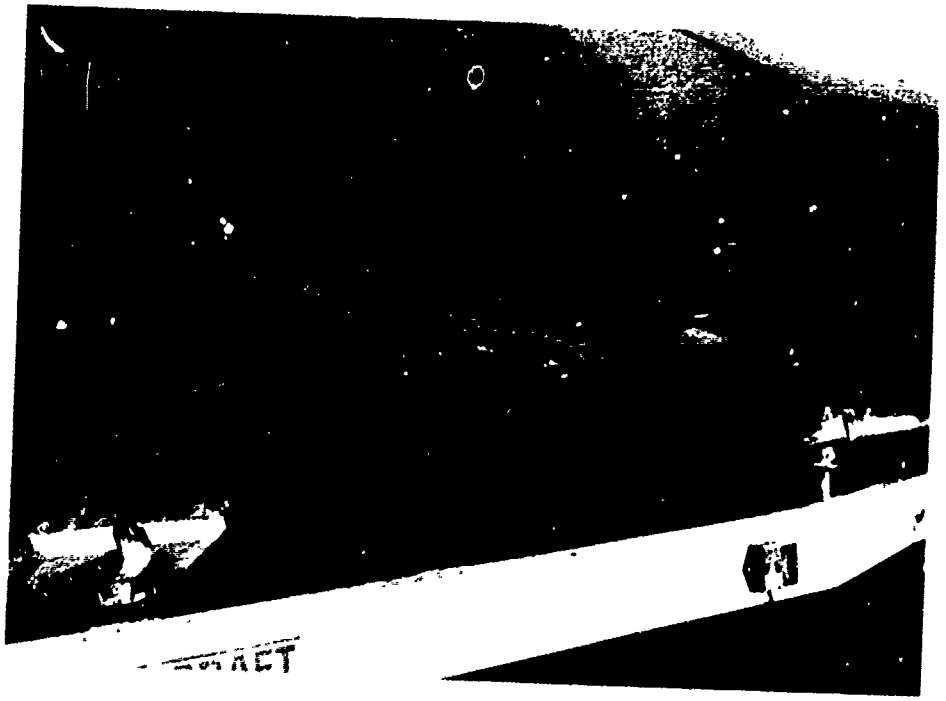
Photograph 5 Sixteen Ft Sidewinder Runabout



Photograph 6. Sixteen Ft Sidewinder Runabout

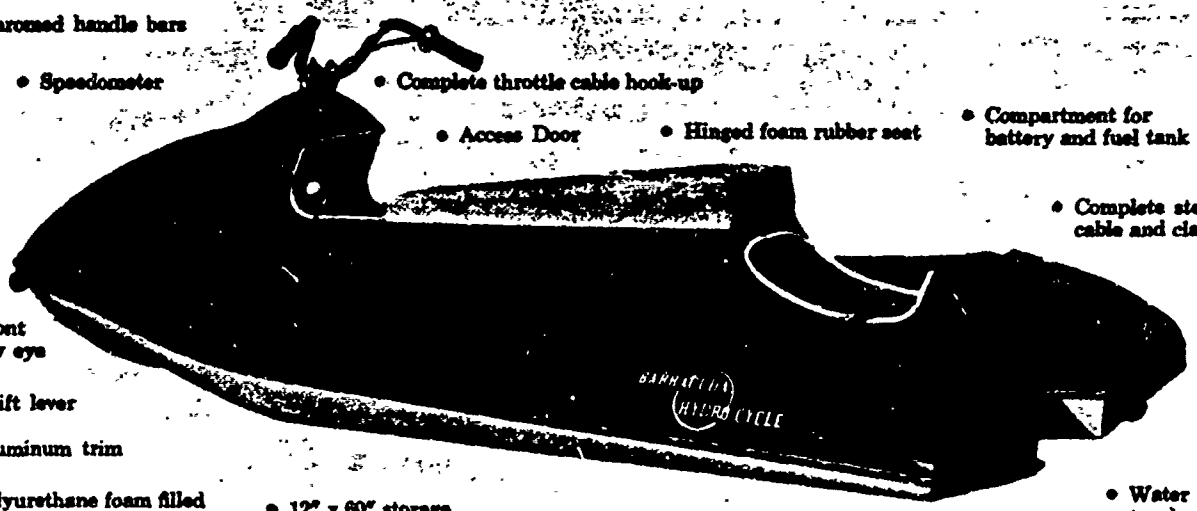


Photograph 7. Sixteen Ft. Sidewinder Runabout (Damaged Area)



Photograph 8. Sixteen Ft Sidewinder Runabout (Damaged Area)

"The Originators of the Sport"



90 DAY WARRANTY

GENTLE AS A KITTEN, due to Hydro-Cycle's unique design features. With today's modern, electric starting engines you can select the right power plant for your family. An easy to reach shift lever for forward, neutral, and reverse provides quick, easy control and may be connected to any standard control cable. The motorcycle type handle bars that turn the motor give quick, smooth performance. In addition, you have the motorcycle twist grip-hand throttle that provides easy control at all speeds plus, for added safety, the hand throttle allows the engine to automatically shut off when the throttle is released. The best feature of all is the price of the Barracuda which makes all this fun yours for very little. Whether it be your first experience in the pleasures of boating, or as a fun addition to your present cruiser, you will be delighted with its performance.

PERFORMANCE CHART

Engine Size	No. Riders	Approx. M.P.H.	No. Skiers	Approx. M.P.H.
9.2 H.P.	1	18 - 20		
	2	14 - 16		
20 H.P.	1	24 - 26	1	20 - 21
	2	22 - 24	Child	18 - 20
	3	20 - 23		
35 H.P.	1	34 - 35	1	30 - 33
	2	32 - 34	1	29 - 31
	2	32 - 34	2	26 - 30
	3	28 - 32	2	2

Hydro-Cycle reserves the right to make changes at any time, without notice, in prices, colors, materials, equipment, specifications and models, and also to discontinue models, or make improvements without incorporating such changes in previous models.

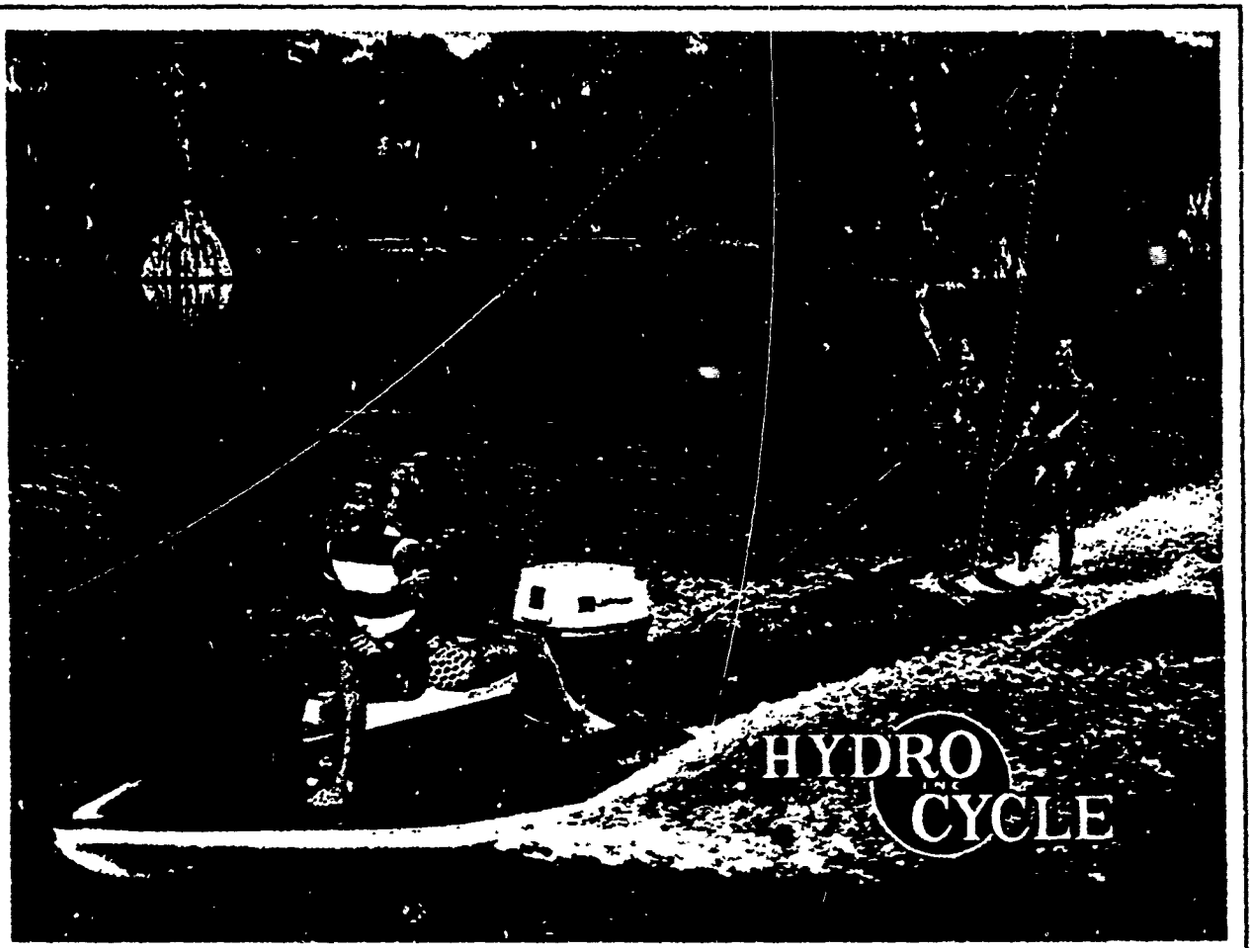
SPECIFICATIONS

Weight: Approx. 200 lbs. less engine
Width: 60 inches at rear
Length: 9 feet
Height: 28 inches without handle bars
Shipping Weight: 215 lbs.
Maximum Recommended HP: 35 HP

HYDRO CYCLE
Patent Pending

215 E. ALMA ST.
SAN JOSE, CALIF. 95112
PHONE (408) 293-1021

DEALER



BARRACUDA

with a 35 H. P. motor gives a lively ride at an honest 35 M. P. H. As an added feature the Hydro-Cycle "Barracuda" is designed to fit most standard motors. Just bolt one on and you are ready for fun. The beautiful all new Hydro-Cycle "Barracuda" easily carries two people and tows one or two water skiers. All Hydro-Cycles are made with impregnated fun colors that can't chip or peel. The entire hull is foam filled for rigidity, plus making it unsinkable. We let you "pick your power" for your own pleasure. No balance problems with this beauty, your skier can climb aboard from the water with no danger of tipping.

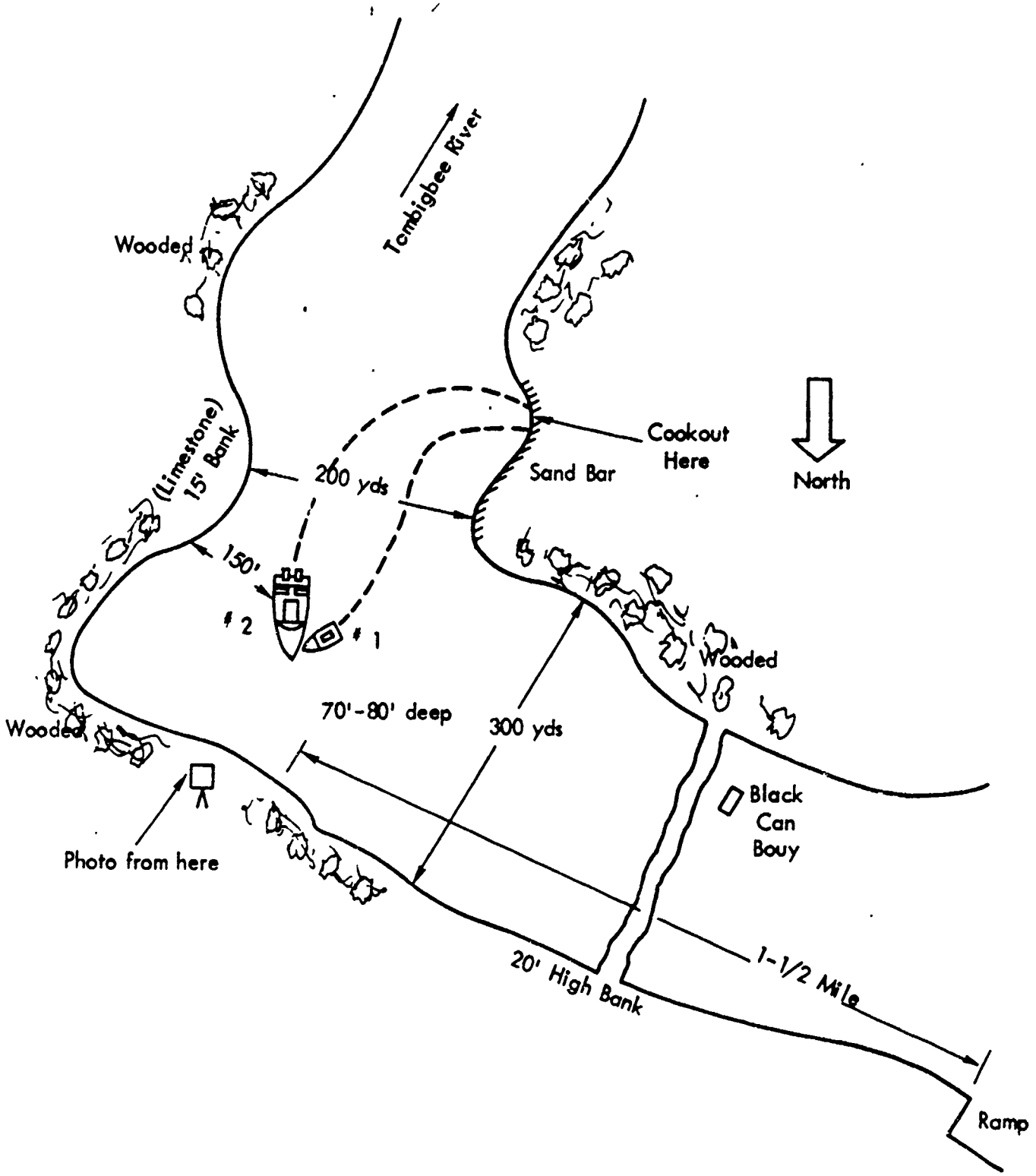
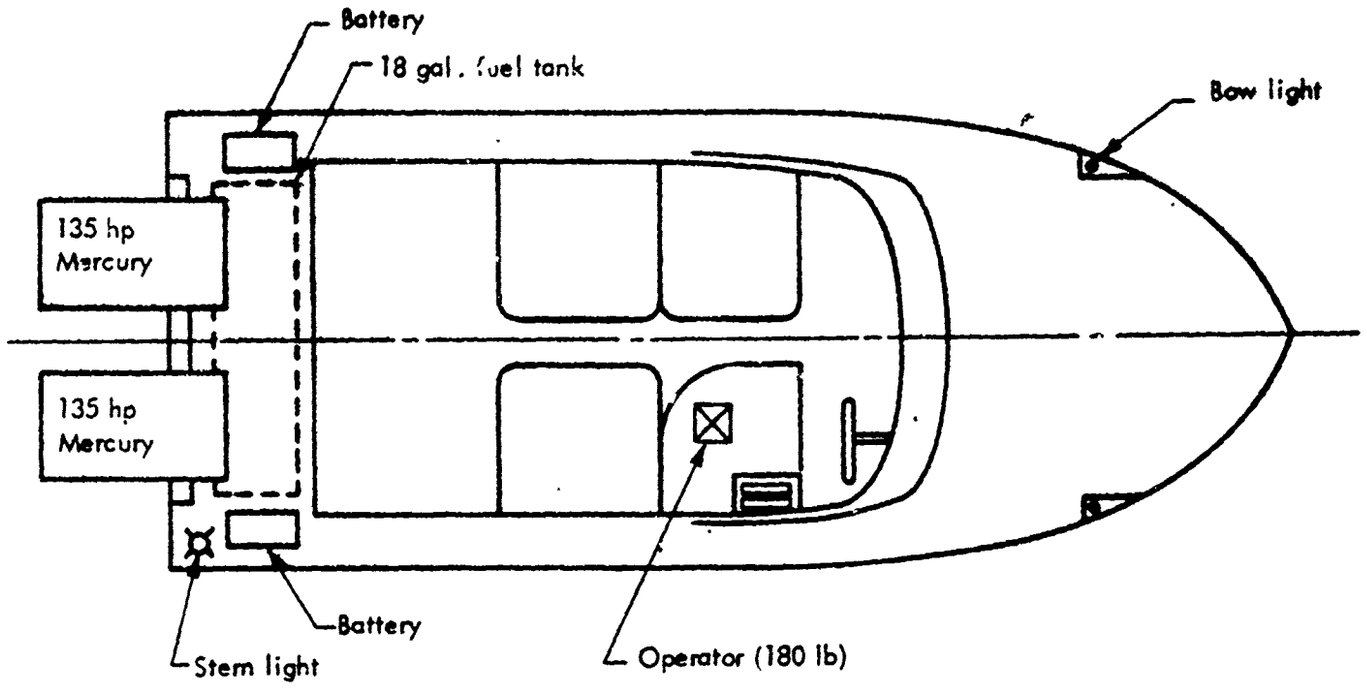


Figure 1. Diagram of Accident Site — Collision No. 75-01

16 ft Sidewinder Runabout



7 ft Hydro Cycle Water Scooter

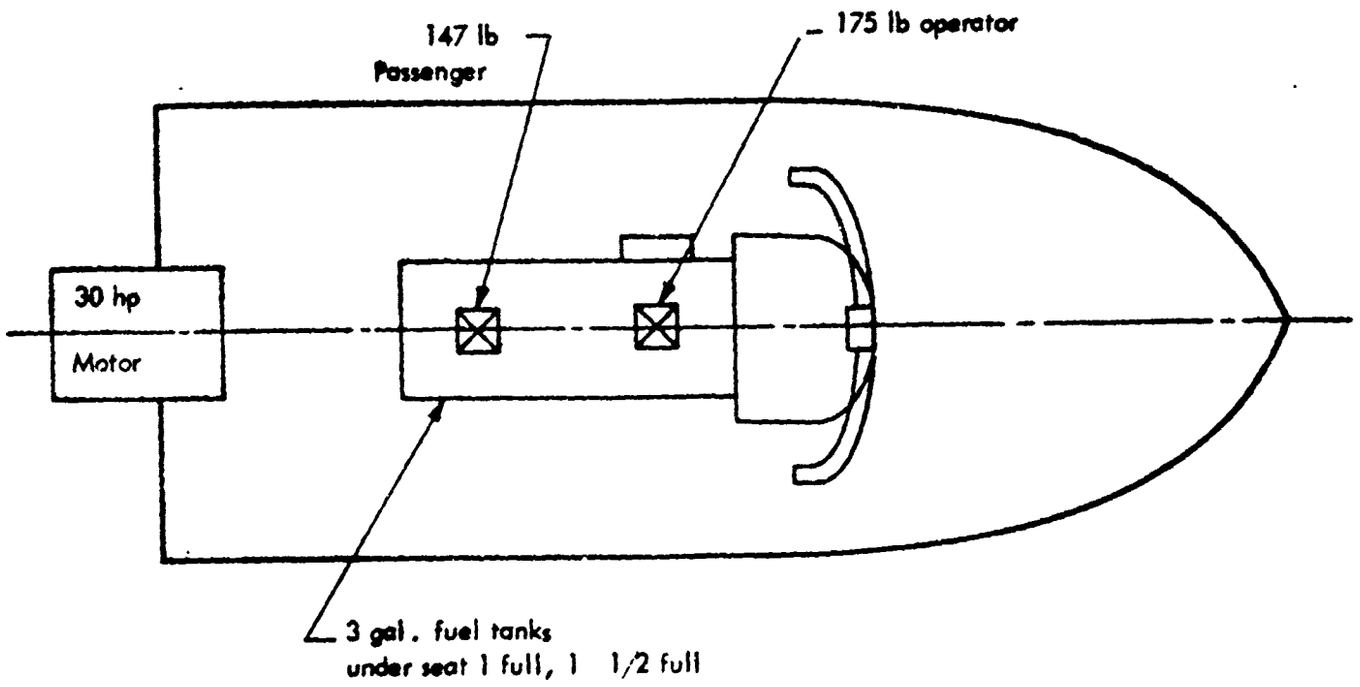
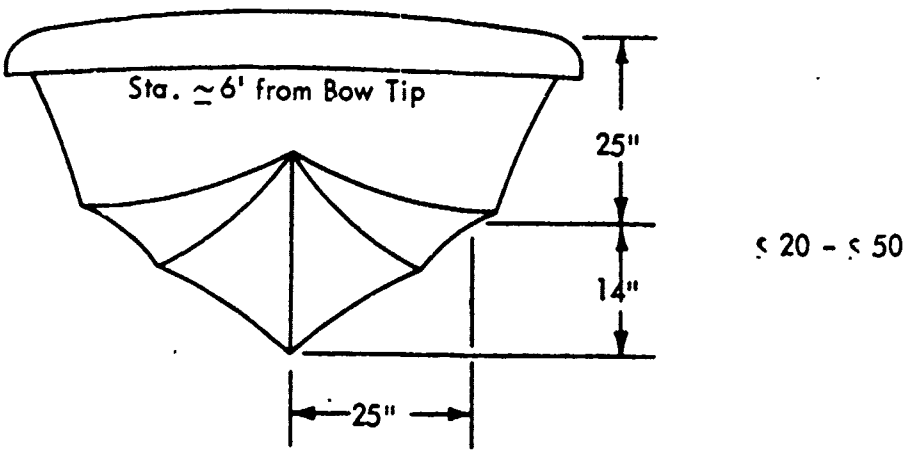


Figure 2. Boat Load Distribution At Time Of Accident

16 ft Sidewinder Runabout



7 ft Hydro Cycle Water Scooter

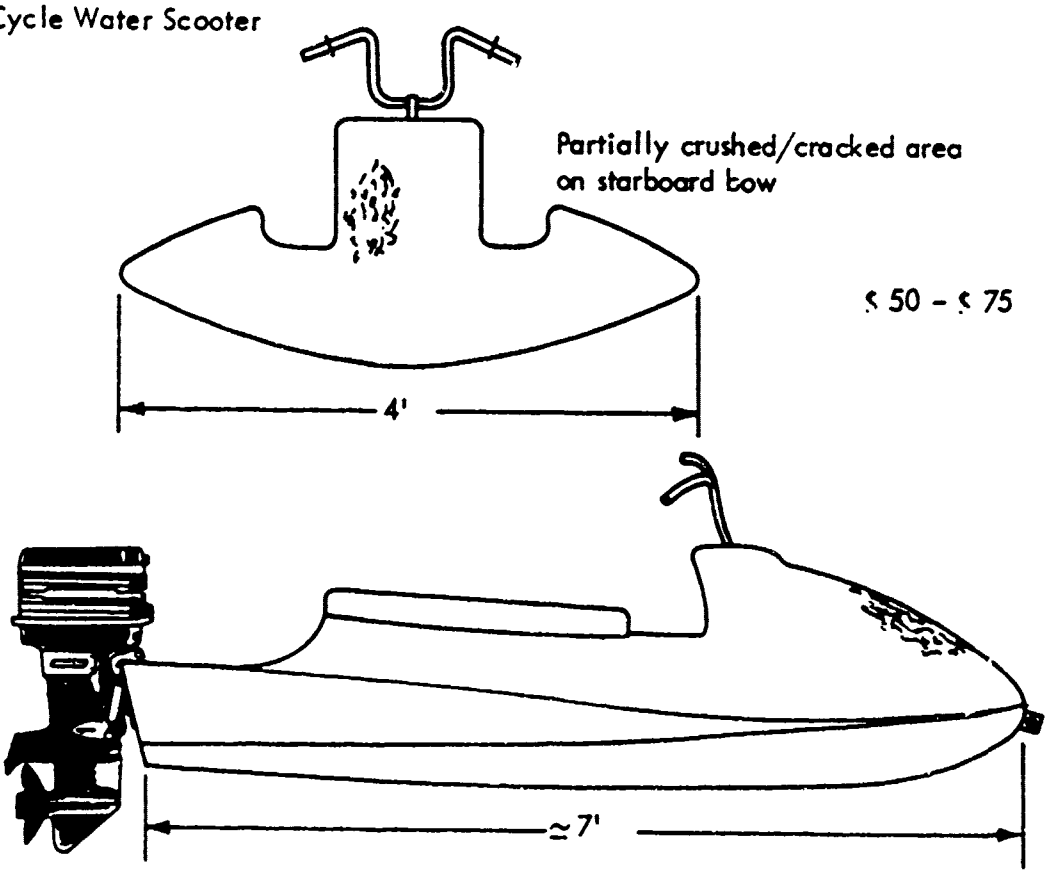


Figure 3. Damage to Boats: Several Nick Marks Less Than 1" Long In Gelcoat At Location Shown on the Water Scooter

ACCIDENT INVESTIGATION REPORT

Date of Investigation: 15 July 1975

Date of Accident: 6 July 1975

Investigation: Collision No. 75-02

SUMMARY – WYLE ACCIDENT NO. 75-323

At approximately 10:30 p.m. on a clear, but very dark, night a 19 ft I/O bowrider runabout with one person aboard approached the center span of a drawbridge. The boat was travelling at between 20 and 25 mph. The operator, who was steering from a standing position in the middle of the companionway, swerved sharply to starboard when a large cruiser suddenly appeared to block the entire bridge span. As the boat turned, the lateral acceleration caused the operator to fall to his knees. Since he couldn't reach the throttle or maneuver the boat, it subsequently collided with the bridge abutment.

The cruiser never stopped. The bridge attendant called the Coast Guard, who transported the injured operator from the boat to an ambulance.

Although the insurance company has not made any decisions as of this writing, it appears as if the boat will be a total loss.

1.0 BOAT OCCUPANT DATA

Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instruction	PFDs Worn
M	37	220	Good	> 500 hrs	None	No

The operator/owner of the boat seemed to be of above average intelligence and possessed a very affable personality. As the son of a Navy officer, he was raised near the water and had participated in boating all his life. As a youngster he was involved in sailing in the Annapolis area, but now prefers small powerboats since powerboat cruising and fishing may be enjoyed by all members of his family.

Most of his boating experience was in boats similar in size and type to the one which he was driving at the time of the collision. In fact, much of his boating experience was in the immediate area of the collision.

2.0 ENVIRONMENT

The sky was clear with a few scattered clouds. A new moon made the sky very dark. The air temperature at the time of the accident was approximately 72 degrees. The water temperature was also 72 degrees. There was almost no wind and little or no current; therefore, the surface of the water would have been glassy smooth if there had been no boats in the area. In actuality, the weather was so good that the operator noticed an unusually large number of boats on the river for that time of night.

3.0 NARRATIVE OF ACCIDENT

The following narrative was formulated from interviews with the owner/operator, the bridge attendant, and the marina operator who salvaged the boat.

3.1 Pre-Accident

The boat owner worked around the house during the day of the collision. Late in the afternoon, he picked up his new boat from a local dealer and launched it at a public launch ramp on the Severn River at about 1800. Upon reading the engine manual, the owner discovered that he was supposed to run the engine at various speeds and not keep it at one speed for a very long time during the first few hours of operation. Since he wanted to take his family for an outing across the Chesapeake Bay on the following day, he intended to finish the break-in procedure that night. He ran the boat up and down the Severn River until 2030, when he drove it up one of the Severn's tributaries to the dock behind his home. He ate dinner and took his son to a short ride in the boat. After returning his son to his dock, he resumed the break-in procedure.

He noted that the boat ran well, the steering was easy and did not tend to pull one way or the other. The controls operated easily. In all, he was quite pleased with the way his new boat handled.

At various times during the evening he stopped by friends' houses to show them his new boat. These people obviously lived on the water on one of the many tributaries of the Severn River.

He commented that there was more than the normal amount of boat traffic, and that this was probably due to the unusually fine weather.

Just prior to the accident the owner reported that he was heading up river at about 20 mph. He had no speedometer aboard, but felt that he was going that fast. He hugged the left side of the river close to the Naval Academy bulkhead because he wasn't sure how deep the water was on the right side of the river. He had heard that it was shoaling. Just as he approached the Severn River Drawbridge, which he had gone under at least a dozen times that night, he turned to starboard to align himself with the main span (see Figure 1). He was several hundred feet from the bridge when he felt that he was properly aligned, perpendicular to the starboard side of the span. He headed for the span but didn't reduce the throttle setting. He never did when going through the bridges along the river, and, in fact, he couldn't have from his position in the boat.

He scanned the area behind the bridge for moving red, green, or white lights. He saw none and assumed that there wasn't any other bridge traffic. He was standing in the middle of the boat between the two seats and steering with his right hand on the top of the wheel. Since the throttle/shift lever was located on the coaming, he would have had to lean over the seat or kneel on it in order to reach the handle.

He said that he always stood in the center of the boat, beside the helmsman's seat when driving his boats at night. He felt that he had to see over the windshield in order to gain sufficient forward visibility. To him, standing beside the control station was better than sitting on the top of the seat back rest because that tended to tear the upholstery.

He saw no boat navigation lights on the other side of the bridge. However, he related that navigation lights were very hard to see at this particular bridge because there are so many waterfront houses, street lights, and automobile lights on the shore behind the bridge.

3.2 Accident

As he was approaching the bridge span, the operator saw a large cruiser approaching from the other side of the bridge. There were no navigation lights on the cruiser. The cruiser was coming very fast, throwing an enormous "bow wave," and was approaching the span at an angle from this boat operator's left to right. The cruiser continued under the span and this boat's operator maintained his course until it suddenly became obvious that the cruiser was not going to straighten out under the span, but was going to continue a diagonal course under the bridge and ultimately ram this boat. The operator had only a split second to make a collision avoidance decision. He said that his options were:

- Turn left and try to pass the cruiser starboard to starboard
- Continue straight and try to shoot the rapidly diminishing gap between the cruiser and the right bridge abutment
- Quickly swerve to the right in an attempt to avoid going through the bridge.

He decided to turn right. He turned the wheel about 1/2 to 3/4 of a revolution. The boat turned and the lateral acceleration pushed him to port. He hung onto the wheel and fell to his knees. At this point he must have turned the wheel to the left or possibly let go of it and it went to the left on its own. He doesn't remember. He does remember looking up, through the windshield just as the bridge abutment was closing in. He was thrown into what he believed to be the windshield frame when the boat hit the abutment. The blow to the forehead rendered him unconscious. The time was now approximately 1030.

The boat had actually taken a zig-zag course turning first to the right, then to the left. It had gone around the wooden structure that protects the concrete bridge abutment and had bounced off the back side of the wooden structure. The boat proceeded parallel with the wooden structure for approximately 10 feet until it came to the point where the wooden structure passes beneath the bridge at about three feet from the concrete bridge abutment. The boat shot the gap, collided with the bridge abutment and remained lodged between the wooden structure and the abutment.

Meanwhile, the cruiser kept on going. The bridge attendant heard "two or three" bangs and got up, out of his chair in the control house to check the situation. He saw nothing out of the ordinary so he went back to his chair. Actually, the boat had collided on the diagonally opposite side of the span from the control tower. About five minutes later the bridge attendant heard faint cries for help. He grabbed his flashlight and went out on the bridge. Fishermen on the bridge had also heard the cries for help. The boat was spotted and a quick flash of the light showed one person in a boat with blood all over his face.

The bridge attendant went back to his tower and called the Coast Guard while the fisherman on the bridge signalled a nearby boat. Occupants of the boat boarded the stricken craft, held pressure on the occupant's head wound and put an AK-1 PFD on him. The PFD was his and was located on the floor beside him. There were other PFD's in the boat also, actual number unknown. The Coast Guard responded within minutes, removed the operator from his boat and took him to a nearby marina to a waiting ambulance. They then returned to the boat and tied it securely to the wooden structure.

3.3 Post Accident

The boat remained tied to the bridge for two days. In that time, the three foot rise and fall of the tide, currents, and the wash of passing boats resulted in severe secondary damage to the stricken craft. Large bolts that hold the horizontal protective boards onto the vertical pilings ground their way through the port side and bottom of the boat. It filled with water and swamped. The seat assemblies which the owner reported as not being fastened to the floor, floated away along with gas cans, PFD's and other loose, buoyant items. The bridge attendant called the Coast Guard again and reported these items as hazards to navigation. The Coast Guard responded but didn't find any of the items. Apparently other boaters found them first.

The boat was towed off the bridge and to a nearby marina two days after the accident. It is interesting to note that the boat floated bow up. When towed by the trailer eye on the bow the boat initially wanted to float upside down, but as the tow boat picked up speed the boat turned over on its own to an upright, bow up attitude and proceeded to bail itself. By the time the salvage party got to the marina the stricken craft was on the surface and was easily maneuvered into the lifting slings before it could sink again. It was hauled out and at the time of the investigation was blocked up and waiting for the insurance company's repair or declare a total loss decision.

According to the operator, he had consumed a couple of beers during the day, but had had no alcoholic beverages that evening. The marina owner said he thought the operator had been drinking quite a bit, but wouldn't divulge the source of his information.

4.0 FACTS FROM THE BOAT INSPECTION

The 1975 boat involved in this accident was a 19 ft bowrider with a 120 hp I/O propulsion system. The 1300 lb fiberglass hull was of a semi-v configuration with a beam of 86 inches.

As can be expected, bow damage was the greatest, but was localized and was all above the waterline. If the boat had been salvaged before a change in tide, it would probably not have sunk. The wooden structure damaged a four foot section of the port bow while the corner of the concrete bridge abutment damaged a two foot wide section of the starboard bow.

The boat itself is lightly constructed with a pop-riveted shoe box type overlapping hull to deck joint. Upon impact the pop rivets failed, and the joint opened up for a distance of about six feet back from either side of the bow.

The deck structure crushed, as did the hull. Since this boat had no secondary supporting structure under the foreward deck area the deck and hull buckled and allowed the abutment to advance about 1-1/2 feet into the forward portion of the boat. The advancement of the abutment into the boat was finally stopped by the horizontal forward seat portion of the deck structure. The crushing effect of the relatively thin fiberglass structures absorbed the energy of the impact at a slower rate than if the structure would have been more solid and may have had an effect on the relatively minor injuries that were sustained.

Neither the windshield, its aluminum frame, or the steering wheel were damaged so it was impossible to determine exactly what the operator hit his head on.

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

The operator was not familiar with the turning dynamics of his new boat. Obviously, he would not have turned right to avoid the collision if he thought that the lateral acceleration would knock him off his feet.

One could say that he shouldn't have been operating the boat from a standing position beside the control station anyhow. But was he forced into that by the manufacturer? Many older runabouts (back in the wood boat days) had windshields that hinged open. Most quality cruisers still include opening windshields forward of the control station. Most contempory runabouts have fixed windshields. They are cheaper and look better since the frames can be thinner and they can be curved instead of faceted. So boat operators must either stand or kneel on the seat, or sit on the top of the back rest to see over the windshield.

If we assume that all controls and displays are designed to be optimally located from the seated position, then they must be less than optimally located from the standing, kneeling, or sitting on the back rest positions. In fact, they are. Reaction times are greatly increased.

In this case, the operator had time and room to turn and avoid the collision. Even though he was standing he was able to swerve and miss the protruding point of the wooden structure that protects the bridge abutment. If he could have continued his turn he would have avoided the collision. If he were seated at the time he could have turned and throttled back. There would have been no collision.

He felt that he was not speeding. Running at displacement speed in a planing boat is frustrating. He couldn't see well at hump speed. Therefore, he chose planing speed as do many other operators of similar boats.

He had no spot light to shine ahead and, in fact, said that he didn't like to use them because they affected his night vision. He said that his 360° white light didn't bother him as long as he didn't look aft. Then he couldn't see well for a few minutes.

He wasn't wearing a PFD and in fact never wore one; however, he always had one close by, just in case. In this case he didn't need one because he wasn't thrown out of the boat. However, if the dynamics of the crash had been just slightly different, he could have been injured, and tossed out of the boat. Without the PFD he would probably have drowned.

The operator didn't see the cruiser on the other side of the bridge and, therefore, assumed that its navigation lights weren't on. In fact, the cruiser was heading straight at him. The cruiser lights, if they were on, were not moving in relation to the background and, therefore, blended in with the many shore lights behind the cruiser.

6.0 PROBABLE CAUSES OF COLLISION

The most probable causes of the collision are:

- The operator was proceeding too fast for conditions
- The operator was unfamiliar with the dynamics of his new boat. He attempted to make a hard right turn while standing in the middle of the boat beside the control station. The resultant lateral acceleration knocked him off his feet. He then lost control of the boat.

7.0 DYNAMICS/ANALYSIS OF COLLISION

1) It probably wouldn't have happened if the operator would have been seated in the proper position. He was out of position because he couldn't see through the windshield. A folding windshield could have prevented the collision. This could be particularly effective if coupled with some method to keep the operator in his proper driving position.

2) The control station of this boat is fairly far forward. It would be interesting to study the effects of lateral acceleration as a result of the fore/aft position in a boat. Perhaps results of lateral acceleration studies as well as visibility studies and vertical acceleration studies could result in an optimum control station location for this type of boat.

3) The fact that there was no reinforcement structure under the fiberglass skin at the bow resulted in a severely crushed bow. But the energy absorbing qualities of the crushing of the fiberglass slowed down the deceleration rate and may have prevented more serious injury to the operator.

4) Operator education stressing speed reduction at night and the dangers of operating a boat while not in the proper driving position could have prevented this collision.

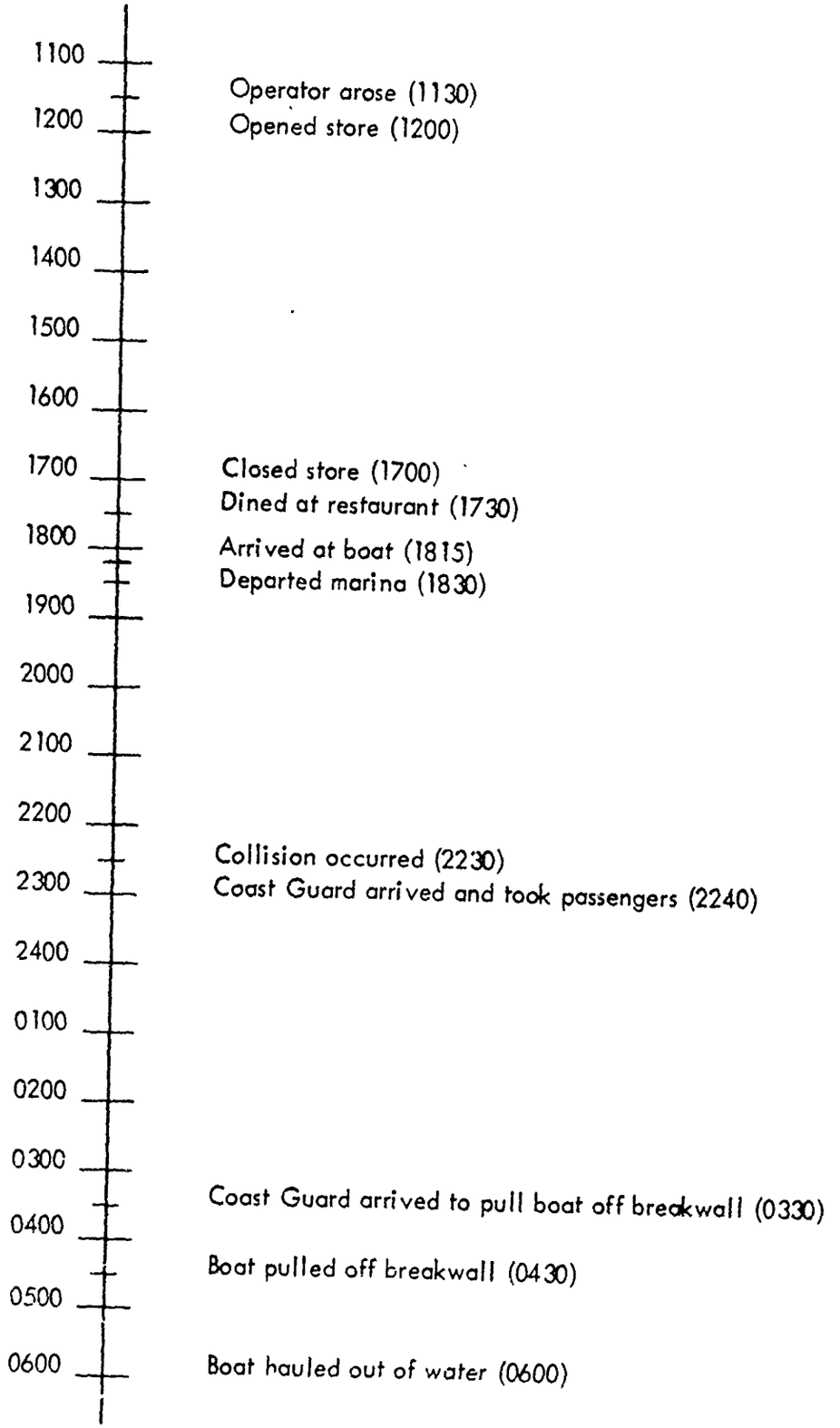
5) Stricter speed laws could have prevented this collision.

8.0 OTHER PROBLEM AREAS

A ventilation problem was discovered in the engine compartment of this boat. It had nothing to do with the collision, but could have caused an explosion. It might be worth while to check with the manufacturer to see if this was the only boat produced in this manner.

The hose extending from the transom mounted blower to the bilge was too long and was laying in the lowest portion of the bilge. Two inches of bilge water had filled the hose more than half full. It would be entirely possible to expect a normal amount of bilge water to totally cover the vent hose, thereby rendering the blower useless. The blower would still run and the operator would, of course, count on it to do its job. See Figure 3.

TABLE I. TIME LINE OF EVENTS IN THE ACCIDENT



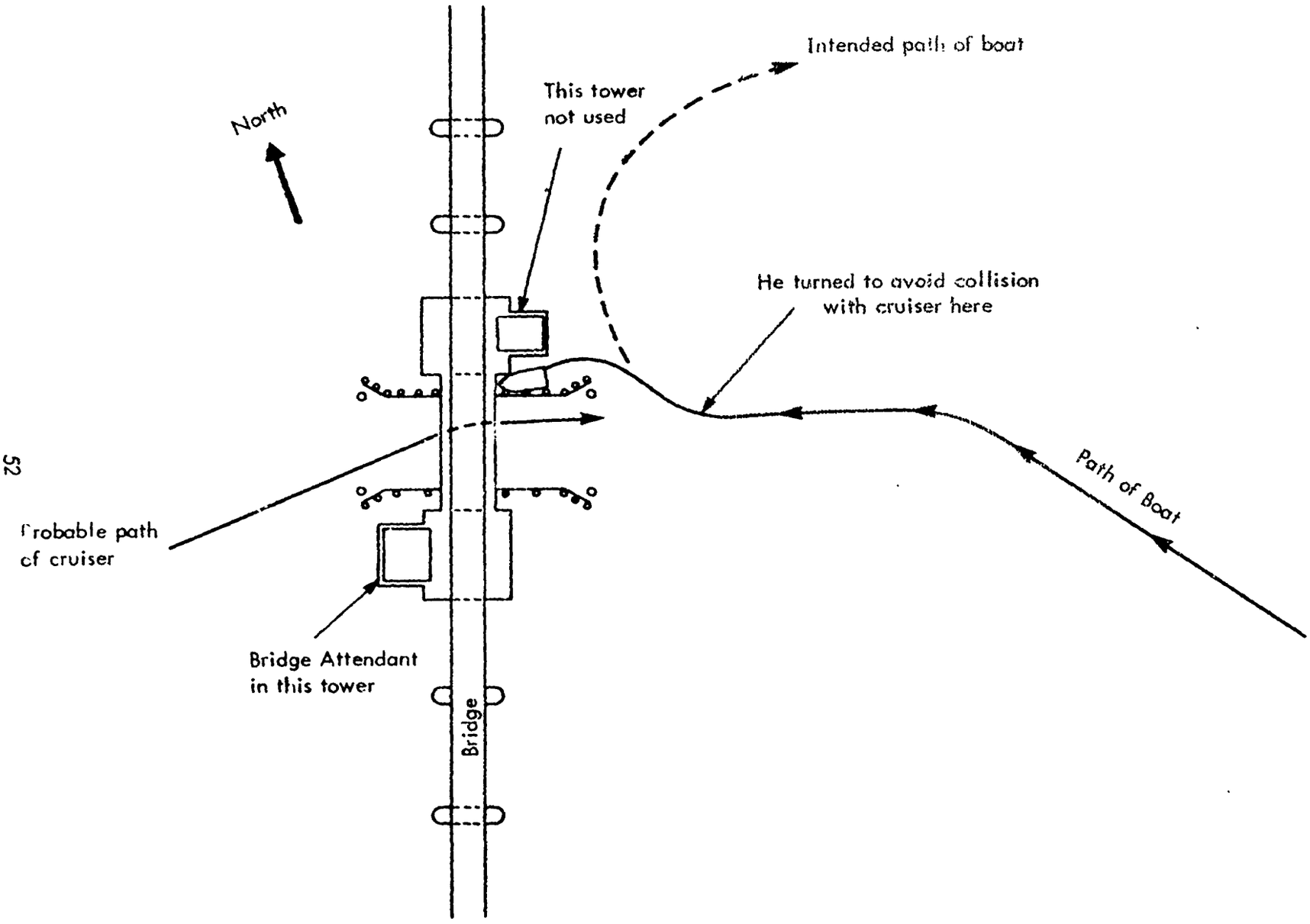
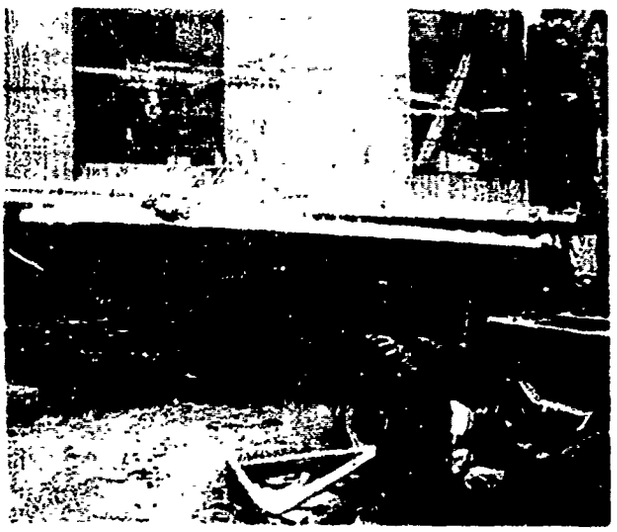
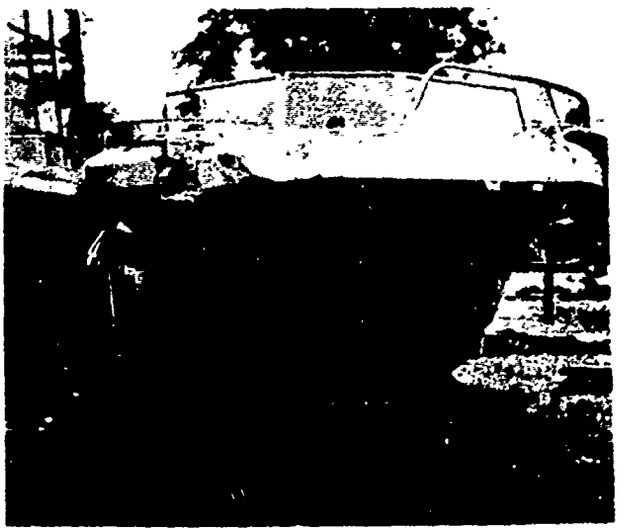


Figure 1. Collision Area Diagram

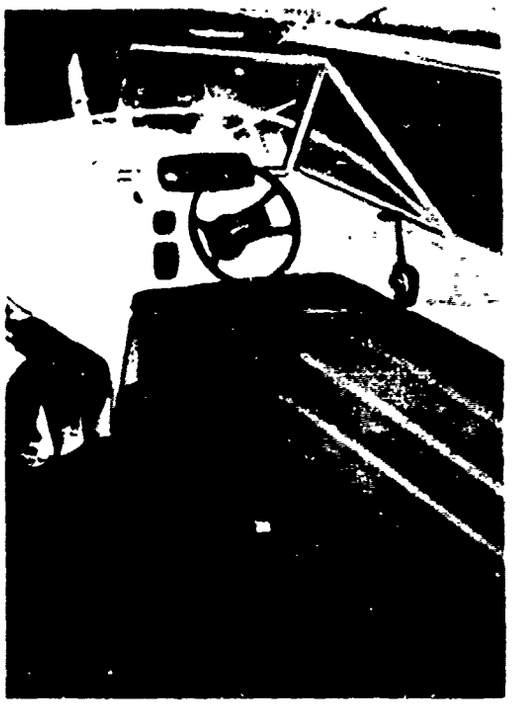


Profile



Bow Damage

Secondary Damage



Cockpit Area

Figure 2. Damage to Boat

Figure 3. Arrow Indicates End of Blower Ventilation Tube in Bilge Water

ACCIDENT INVESTIGATION REPORT

Date of Investigation: 1 July 1975

Date of Accident: 7 May 1975

Investigation: Collision No. 75-03

SUMMARY — WYLE ACCIDENT NO. 75-088

This accident involved one boat colliding with a fixed object. At approximately 5:35 am on May 7, 1975, two men set out on a fishing trip from a launch ramp located on a river. The boat was a sixteen foot open fisherman type powered by a forty horsepower outboard motor. A four horsepower trolling motor was installed on the starboard side of the transom. According to the operator, the men travelled down stream at a speed of 4-6 mph for a distance of approximately 0.4 miles. The river current was estimated to be approximately 2 mph. The operator and passenger almost simultaneously spotted a dark object straight ahead and only a few yards away. The operator shifted the motor into reverse in an attempt to stop the boat before hitting the object. The collision avoidance effort on the part of the operator was too late and the boat hit the object bow on. On impact, the operator was thrown forward into the steering console and the passenger was thrown forward into the bench seat. The operator was not injured, but the passenger received severe head injuries. After the collision, the operator noted that water was coming into the forward section. He moved to the stern which raised the bow sufficiently to stop the ingress of water. The secondary impact with the steering console caused the cable to unwind from the drum disabling the remote steering. The operator maneuvered the boat back to the launch ramp by holding onto the motor cover.

1.0 BOAT OCCUPANT DATA

Operator/ Passenger	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	# PFD's Worn
Oper.	M	38	190	Good	>300 hrs.	None	No
Pass.	M	68	175	Good	>500 hrs.	None	No

1.1 Owner/Operator

From the interview it was apparent that the owner was an experienced boat operator and fisherman. He had over 300 hours of boat operating experience in the rivers and lakes of southwestern Michigan. He was aware of the passenger's knowledge of boat handling and considered his ability at least equal to his own.

The owner was a machinist by trade and seemed to be of average intelligence. His formal education probably consisted of high school with a machinist trade school. He is a subscriber to a national boating and fishing magazine.

The operator's original statements concerning events before, during and after the accident were very general. Specific details concerning the accident were gained only through direct questioning by the interviewers.

1.2 Passenger

At the time of this accident investigation, it was apparent that the passenger had not recovered from mental and physical injuries resulting from the accident, which precluded an assessment of his mental and physical state at the time of the accident. However, from talking to the passenger's wife and friends, it is assumed that he was of normal intelligence and physical ability prior to the accident. He had over 500 hours of boating experience in the rivers and lakes of southwestern Michigan.

2.0 ENVIRONMENT

The sky was clear and the wind was calm. The air temperature was estimated at 57°F and water temperature estimated at 48°F. There were street lights and lighting on commercial buildings along the west bank of the river. There were no lights along the east side of the river. Caution lights were installed on the bridge that was being dismantled and according to the operator were inoperative at the time of the accident. The accident occurred approximately 40 minutes before official sunrise. The water depth at the accident site was 15-20 ft.

3.0 NARRATIVE DESCRIPTION OF ACCIDENT

3.1 Pre-Accident

The owner/operator of the involved boat and the passenger had known each other for a number of years and had been fishing together many times. The accident area was a point between the launch ramp and the fishing location. Both occupants had been past this point by boat on numerous occasions and were thoroughly familiar with this section of waterway. The operator had been on vacation since April 23, 1975 and had been past this point to the fishing location seven consecutive days up until May 5. They were aware of the fact that the bridge was being removed; however, the operator stated that the location of obstructions in the vicinity of the bridge area changed from day to day due to the dismantling process.

On the day before the accident (May 6, 1975), the operator (A) contacted the passenger (B) and set up a fishing trip for May 7. (A) called the local marine weather station and was briefed on the forecasted weather conditions for May 7. The forecast called for clear skies, calm wind and air temperature in the upper 60's.

A and B went to bed prior to 11 pm on May 6 and got up at approximately 4 am the next morning to prepare for the fishing trip. Both men had breakfast and A hooked the boat trailer to his auto and drove to B's house, arriving at approximately 5 am. The men left B's house at approximately 5:05 am and arrived at the launch ramp 25 miles away at approximately 5:35 am.

3.2 Accident

The boat was launched and the fishing equipment stowed. The transom drain plug was installed just before launching so there was no water in the boat at the start of the trip. The men left the launch area and headed downstream at approximately 5:40 am. Gear aboard was as shown in Figure 1 and the weather as in Section 2.0. It was very dark and the only way that A could keep himself oriented was by reference to street lights and lighting on commercial buildings on the east bank of the river. There were no lights on the west side of the river. The river made a gradual bend to the left from the bridge site, making lights on the east bank visible when looking straight down the river channel from the bridge site (approximately 1.5 miles). The brilliance of these lights at a distance of 1.5 miles was not sufficient to silhouette an obstruction in the river channel.

The men travelled a distance of approximately 0.4 miles at an estimated speed of 4-6 mph. A spotted a dark object dead ahead and only a few yards distance. Almost simultaneously, B spotted the object and yelled to A that there was something ahead. A hastily pulled the shift lever toward the reverse position. As the shift lever passed the neutral position, it hung momentarily before going into reverse. The boat impacted the object bow on with A still working with the shift lever. He was not sure if he got the motor into full reverse before the impact; however, after impact, he noted that the shift was in the reverse position. On impact A was thrown forward into the steering wheel and steering wheel console. The force of his body ripped the console loose from the boat hull at the aft end, swinging the wheel and console in a clockwise arc approximately 30 degrees. Movement of the console caused the steering cable to unwind from the steering wheel drum disabling the remote steering. B was thrown forward, face down into the fishing tackle box located on the bench seat immediately in front of him. The plastic windshield was broken in the center bottom and B thinks he broke it with his hand when he was thrown forward, but cannot be sure.

Immediately after impact, A noticed that a large amount of water was coming into the bow section. He could not see where the water was coming in because of darkness. A moved to the stern thinking that the bow would come up enough to stop the ingress of water into the bow. The water stopped coming in and A directed his attention to B. A asked B if he was

hurt and B replied that he would be alright. A could tell that B was injured by his slumped position over the bench seat and the confusion and non-awareness detectable in his speech. The motor was in reverse and still running. The bow was pointed downstream with the reverse speed about equal to the current, so the boat was essentially staying in place. A put the motor in forward gear and started back to the launch ramp sitting astern and steering the boat by the motor cover. He maintained the fastest speed at which he could control the steering. After the collision, A estimated that 50-60 gallons of water came into the boat before he moved to the stern. When the boat came to the launch ramp, A was afraid if he stopped the boat it would sink, so he drove the boat up on the concrete launch ramp. Refer to Figure 2 for sketch of accident area. Photograph 1 and 2 show the location of the bridge at the time of the accident.

3.3 Post Accident

B was taken to a local hospital by ambulance. His injuries were diagnosed to be a broken nose, lacerations of the forehead, and a bruised right wrist and hand. He was treated and released. On the afternoon of May 7, he was returned to the hospital because of brain hemorrhaging. His condition was then diagnosed as brain damage which caused the hemorrhage. A subsequent blood clot in the brain and partial paralysis of the right side of the body.

At the time of the accident investigation, he had undergone two head operations. He appeared to be somewhat physically feeble for his size and build and was not very alert mentally. Although his wife said his paralysis had improved, it was evident that some paralysis still existed in his right side. A was not injured during the collision.

It is reasonable to assume that no alcohol was consumed by the occupants prior to the accident. When A was asked indirectly if alcohol had been consumed the night before the accident, he voiced an almost violent opposition to drinking alcohol.

TIME SEQUENCE

4:00 a.m. -	Men arose to prepare for trip.
5:00 a.m. -	A arrived at B's house with boat/trailer.
5:05 a.m. -	A and B left B's house for launch ramp.
5:35 a.m. -	Arrived at launch ramp.
5:40 a.m. -	Left launch ramp and headed downstream
5:50 a.m. -	Boat impacted steel structure
5:50 - 5:51 a.m. -	A moved to the stern to stop water ingress and started back to launch ramp.
6:15 a.m. -	Arrived back at launch ramp and got in automobile to transport B to hospital.
6:35 a.m. -	Arrived at hospital.

4.0 FACTS FROM THE BOAT INSPECTION

The boat was a 16 ft 1969 model Sea Numph of welded and riveted aluminum construction. The boat was powered by a 40 horsepower Johnson outboard motor. A 4 horsepower Mercury outboard motor was installed on the transom, starboard side for trolling.

The boat was a typical semi-v bottom open boat used almost exclusively for fishing. A 1/4 inch plywood homemade bow cover had been installed by the owner. The cover extended approximately one-fourth the length of the boat aft. A 1/16 inch thick plastic windshield and a 1/4 inch plywood sun roof had also been installed by the owner. A trolling motor mount had been installed on the transom starboard side.

Damage caused by the collision was as follows:

- Large dent in area at the stem midpoint
- Large hole in bow starboard side
- Steering console torn loose from boat hull at aft end
- Plexiglass windshield broken at center bottom

The flotation material consisted of a styrofoam block installed under the three aft seats at the time of manufacture.

There was an open space under the bow seat but no evidence could be found that flotation material had been installed in that location (which is not unusual for that age boat). Refer to Photographs 1-4 for boat details.

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

The operator stated several times during the interview that he felt somewhat responsible for the accident, but could not recall anything specific that he should have done differently. It is very likely that he knew he was going too fast for existing conditions, but would not admit this even to himself. He was thoroughly familiar with the accident area; therefore, the unlighted obstruction was probably sufficient justification for him to feel that this was the sole cause of the accident.

No doubt the homemade plastic windshield restricted the operator's forward visibility. Whether or not this fact contributed to the accident is unknown.

6.0 PROBABLE CAUSE OF ACCIDENT

The following items are most likely the major factors in causing this accident.

- The unlighted obstruction was certainly a major factor in this accident. The operator stated that Coast Guard personnel on duty at the time of the accident verified that the caution lights on the bridge were inoperative at the time of the accident.

- The boat was probably travelling too fast for existing conditions. The operator stated that the speed was 4-6 mph; however, on examination of the bow damage caused by the impact and calculations as to the probable impact velocity, it is assumed that the boat speed was at least 15 mph. Refer to Appendix A for calculations.

- There was no spotlight on board. The operator was confident he could avoid obstructions without a light since he was thoroughly familiar with the area.

- The plexiglass windshield that had been installed by the operator probably impaired forward visibility.

7.0 DYNAMICS/ANALYSIS OF THE ACCIDENT

The following is presented, based on the narrative, the boat load distribution, and knowledge of the boat characteristics.

From the load distribution, it can be assumed that the boat was running essentially transversely level with a positive trim angle of approximately 7 degrees. This running angle would allow adequate forward visibility from the helm under normal lighting conditions. Forward visibility was restricted only by the windshield and darkness.

The boat impacted the obstruction bow on and there was evidence that the occupants were thrown forward parallel with the longitudinal axis of the boat. Therefore, it is assumed that the boat remained transversely level during and after the impact.

The operator stated that he may have tried to turn the boat to starboard to avoid the obstruction. The steering wheel was located at knee level to the seated operator which required steering control to be accomplished by grasping the steering wheel on the top portion. The operator's right hand was on the gear shift at the time of impact. Due to the location of the steering wheel, it is reasonable to assume that a collision avoidance maneuver requiring a turn of over 15-20 degrees could not be accomplished with one hand.

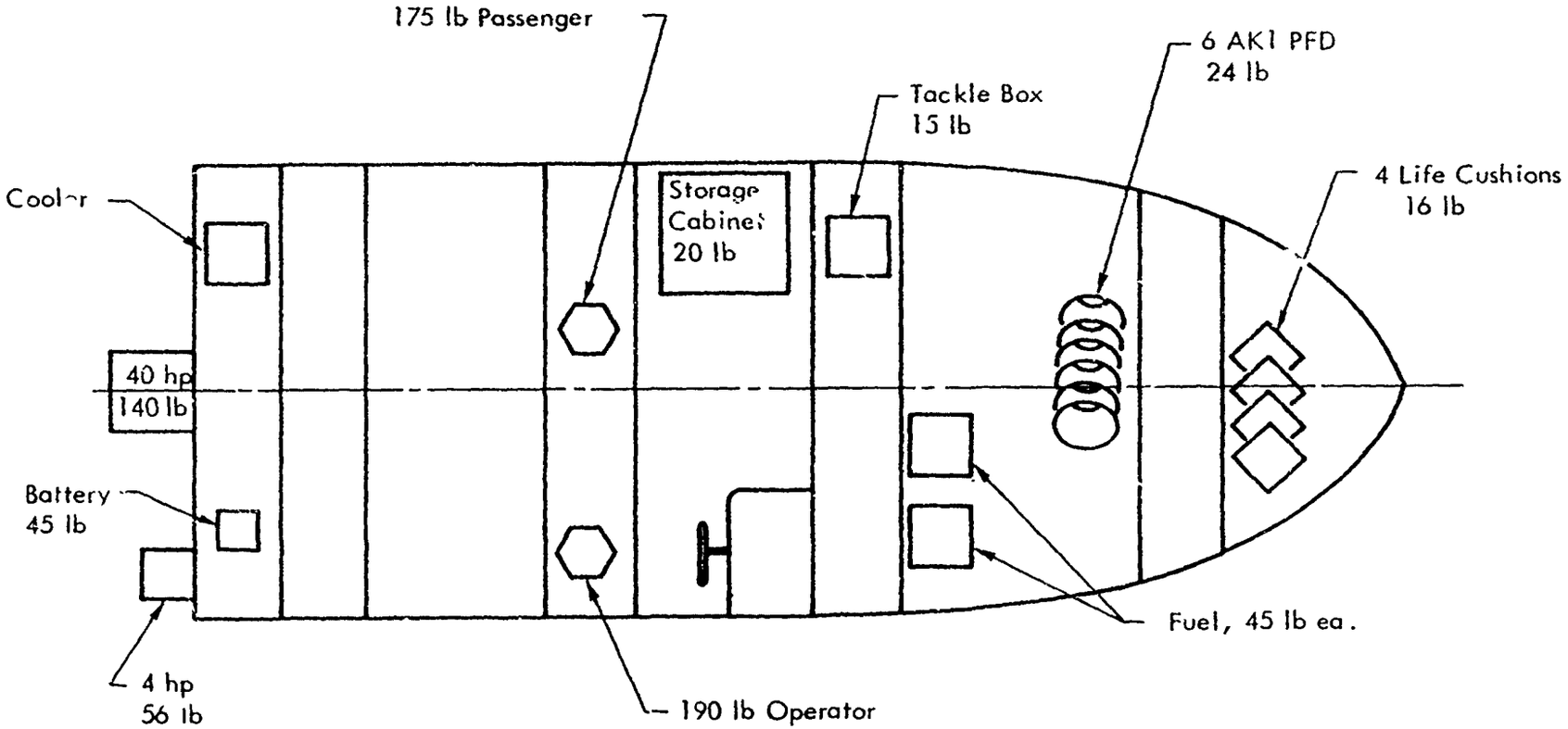


Figure 1. Load Distribution At Time Of Accident

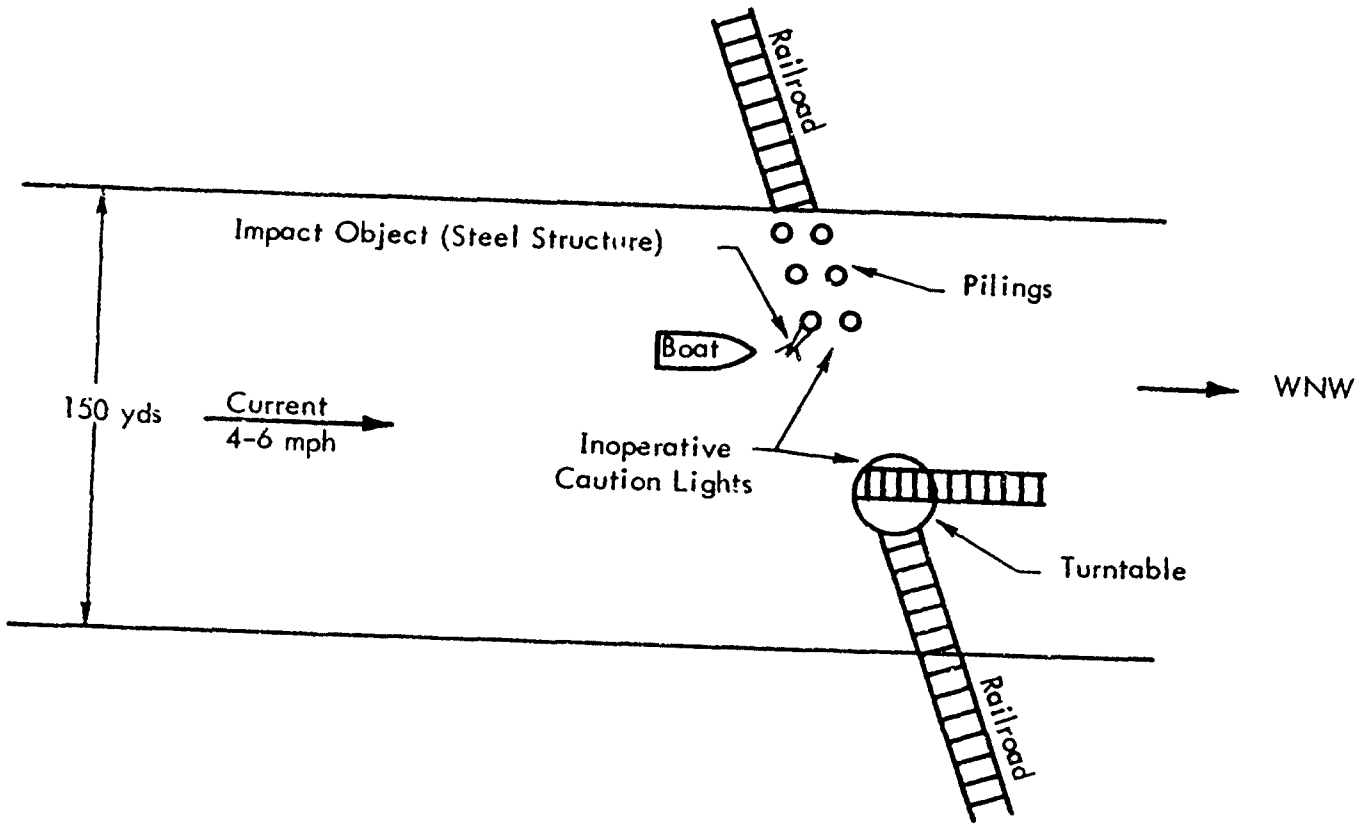
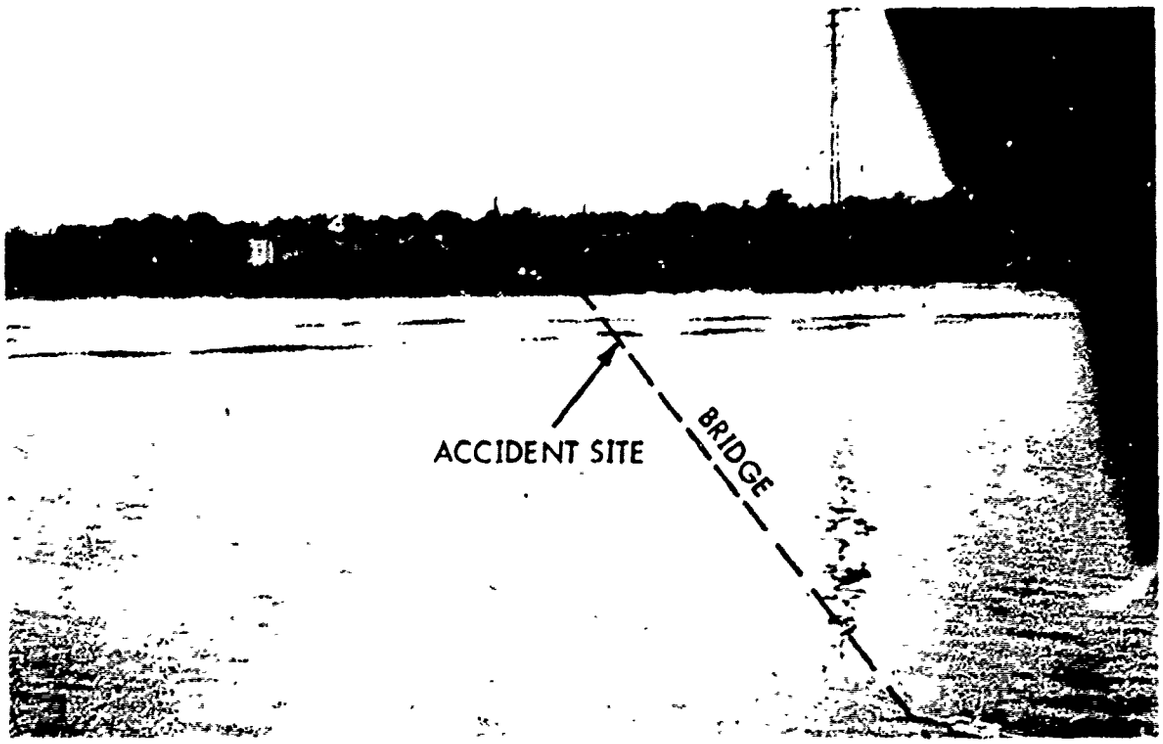


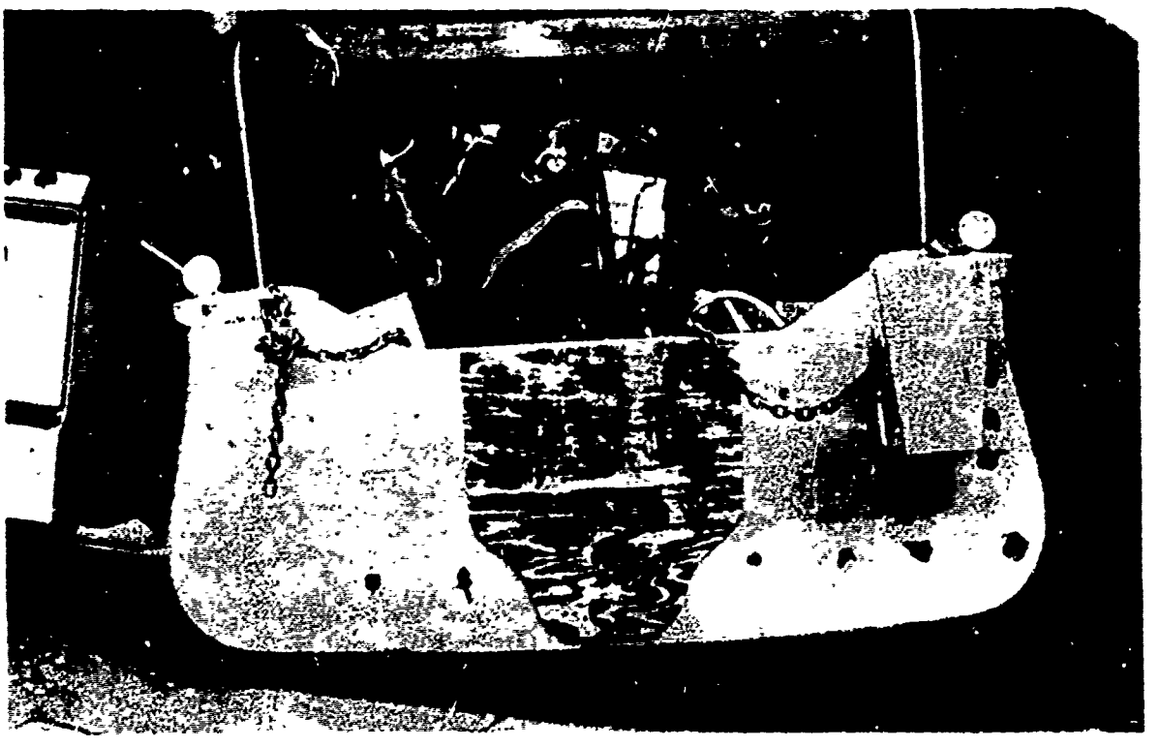
Figure 2. Accident Location

Photograph 1. View From Accident Area To Launch Area

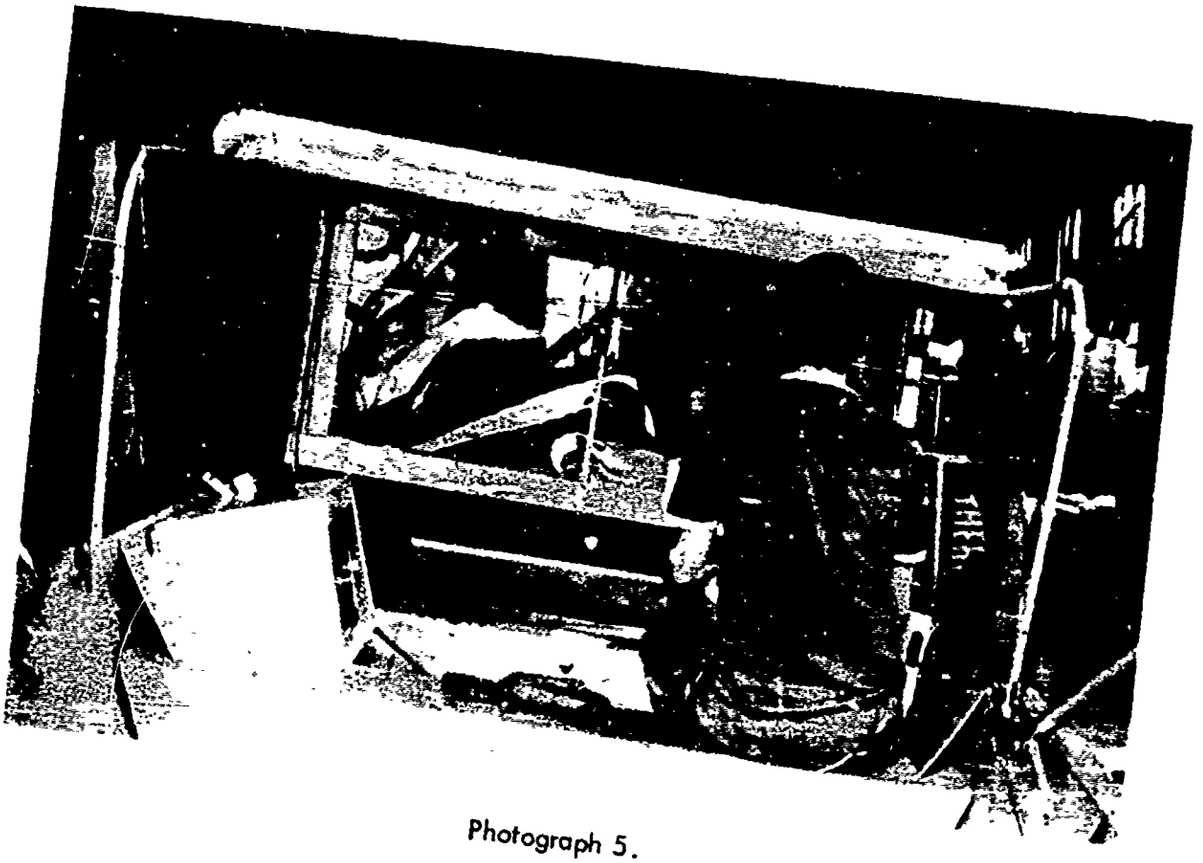


Photograph 2. Bridge Location

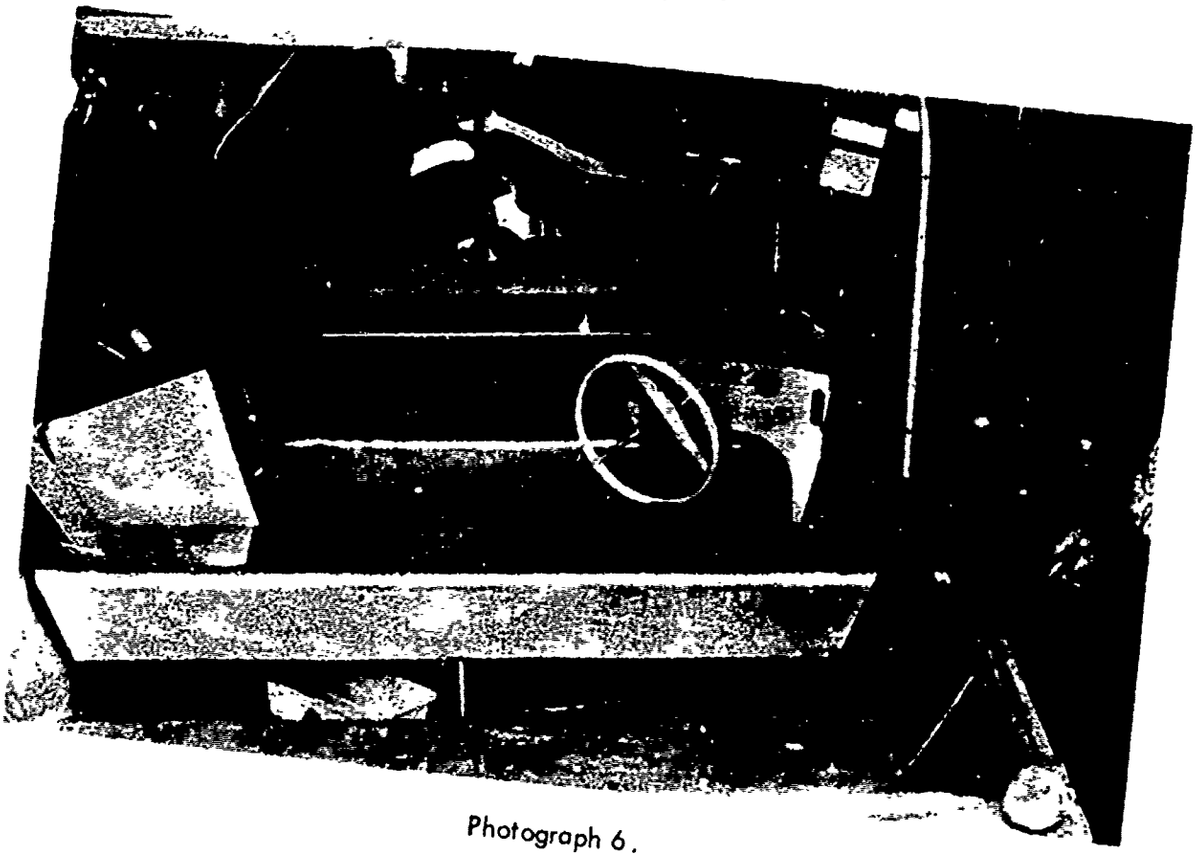
Photograph 3.



Photograph 4.



Photograph 5.



Photograph 6.

APPENDIX A — PROBABLE IMPACT VELOCITY

Estimation of Relative Velocity at Impact

The amount of damage done to the boat structure by the impact appears to be far greater than what experience tells us can be done by the relatively low velocity reported by the owner/ operator. This damage consists of the bow structure being collapsed and crushed back to a permanent set of some 8-10 in. and a railroad tie piercing the front side of the hull about three feet aft of the bow.

For purposes of estimating velocity, it will be assumed that the primary impact was bow-on and that the boat then swung so that the curved front side skin of the boat hit the jutting railroad tie at right angles so that puncture of the skin was possible. Photographs of the damaged bow indicate that its impact must have been nearly bow-on since the ensuing structural crushing is roughly symmetrical on either side of the centerline of the boat. If the initial impact were with the tie, this would absorb some of the kinetic energy of the boat so that the velocity at impact calculated below would be on the low side.

In order to estimate the speed of the boat at impact, we will estimate the kinetic energy of the boat and its fixed contents and equate this to an estimate of the amount of energy necessary to do the observed structural crushing of the bow of the boat. From this equality, the velocity as the only unknown can be determined.

Kinetic Energy of Boat and Fixed Contents

The boat has been estimated to weigh about 400 lb. The fixed equipment, including motor at 140 lb, and fuel at 90 lb, is estimated to weigh no more than another 400 lb. Note that the operator and passenger are not included in this calculation of kinetic energy since their contribution will be towards a secondary impact, when they are slammed forward into the interior boat structure, rather than to damage done in the primary impact.

$$K.E. = (1/2)\, MV^2 = (400 - 400)V^2 / 2 \times g$$

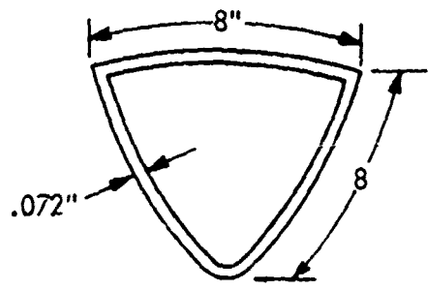
$$= 800\, V^2 / (2 \times 32.2) = 12.422\, V^2$$

Energy Absorbed In Crushing Of The Bow

This estimate will be made by first estimating the force necessary to cause the hull aluminum to crush into a permanent set condition and then multiply this by the distance that the bow has been crushed in. Here we are faced with making reasonable estimates as to the alloy, gage, and temper of the metal plus the geometry of the bow prior to the crushing.

The boat was 15'9" long, 6' 1/2" wide and 2' deep. Then taking the weight of 400 pounds and spreading it over the surface to be covered, and taking into consideration the concentrated weights due to the bow casting, the gunnels, stringers, and motor mounting structure, we find that this weight corresponds closely to the standard aluminum alloy gage of 0.072". This is a gage that could well be used for a quality aluminum boat. The next standard gage higher 0.081" is too thick for the type of forming done in skinning a boat. The next lower gage of 0.063" is a possibility, but if this is the case, the weight estimate for the boat of 400 lb is too high.

In order to collapse the bow sufficient force must be applied to cause permanent yielding of the aluminum over an area of a curved triangle some 8 in. on a side. See sketch below.



The area of metal involved would be approximately $3 \times 8 \times 0.072 = 1.728$ in^2

The depth of collapse is estimated as at least 8 in.

The strength of the aluminum is the next thing to try to determine. Normally, we would feel that alloy 5052 would be used due to its ready availability, weldability, and excellent corrosion resistance to marine atmospheres. However, the boat shows definite evidence of structural riveting which could be an indication that it is fabricated from a heat treatable

alloy such as clad 6061-T6. If this latter alloy were used, the minimum yield strength of the material would be 35,000 psi. If ally 5052 were used, the minimum yield strength would depend upon the temper of the material. The relatively gentle curves indicated by the photographs of the boat would indicate that it could be formed out of H36 three-quarter hard material which has a minimum yield strength of 27,000 psi. However, it is more likely that H34 half hard material, which is common in the boat building industry, were used which has a minimum yield strength of 20,000 psi. It is possible but not so likely that H32 quarter hard material were used in which case the minimum yield strength would be as low as 16,000 psi. A boat builder would normally only use H32 if rather extensive stretching or forming were involved.

To be somewhat on the conservative side, we will use the 16,000 psi figure so that the energy absorbed in crushing the bow of the boat would have been approximately:

$$1.728 \text{ in}^2 \times 16{,}000 \text{ lb/in}^2 \times 8 \text{ in}/12 \text{ in/ft} = 18{,}432 \text{ ft-lb}$$

Estimation of Velocity Based Upon Above Assumptions And Numbers

Equating kinetic energy to energy absorbed, we find:

$$12.422\ V^2 = 18{,}432 \text{ ft/lb}$$

$$V^2 = 18{,}432/12.422 = 1484 \text{ ft}^2/\text{sec}^2$$

$$V = 38.52 \text{ ft/sec} = 26 \text{ mph}$$

Accuracy Of The Above Estimate

If the above is on the low side, it could be due to our choice of a low strength alloy where a higher strength one was actually used. This could raise the velocity by the square root of the relative yield strength of 35,000 vs 16,000 psi or up to a velocity of 38 mph.

If the gage of the metal were lower, say, down to 0.052 in. thickness, this would be two standard gages lower than our initial estimate, the velocity would go down to somewhat above 22 mph.

If our weight estimates are off by a factor of two, the velocity would go down to 18 mph or up to somewhat below 37 mph.

It is difficult to think of any combination of effects that might reduce our estimate to as low as 15 mph.

PREPARED BY: Dr. C. M. Tyler, Jr.
Structural Analysis Group
Wyle Laboratories

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ACCIDENT INVESTIGATION REPORT

Date of Investigation: 22 July 1975

Date of Accident: 5 July 1975

Investigation: Collision No. 75-04

SUMMARY — WYLE ACCIDENT NO. 75-327

At 2145 on a relatively clear but moonless night, a family and friends aboard a 31 ft cruising powerboat were returning to their home port after a four hour evening cruise. The owner/operator, who was quite familiar with the configuration of the aids to navigation in the harbor entrance, misjudged his distance off shore, couldn't locate one of the flashing lights, and while searching for it, ran his boat up onto the end of a breakwater. The boat came to rest atop of the breakwater about 10 ft from the light that he never saw.

No one was injured and the boat was pulled off of the breakwater within hours after the accident.

1.0 BOAT OCCUPANT DATA

[illegible]	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD's Worn
Operator	M	42	187	Good	500 hrs	No	No
Passenger	F	30	100	Can swim	some	No	No
Passenger	F	41	145	Can swim	500 hrs	No	No
Passenger	F	10	60	Fair	not much	No	Yes
Passenger	M	33	175	Can swim	some	No	No
Passenger	F	20	120	Can swim	some	No	No
Passenger	M	10	60	Can swim	yes, with parents	No	Yes

The owner/operator of the boat had been boating all of his life in the area of the accident. He owned his present 31 ft powerboat for three years and prior to that, owned a similar sized powerboat. Owner modifications to the boat were expertly made with accessibility and maintainability in mind. In general, the boat had been meticulously cared for and was in showroom condition.

It was evident that the owner was safety conscious and experienced. For instance, he had modified his cockpit lazerette with hooks that allowed him to hang all lines, fenders, spare anchors, and spare parts such as shackles around the perimeter of the hatch in such a way that they were instantly available and wouldn't foul each other.

He is an established business man in the community in which he does his boating and is known as a "non-drinker."

Other occupants of the boat included the owner/operator's wife, another couple, a 20 year old girl, and two ten year old children, one of which was asleep in the forward berth at the time of the accident.

2.0 ENVIRONMENT

The night of the accident was very dark. It was partly cloudy with no moon. The temperature was 73 degrees, the wind was blowing at about 7 mph, and the seas were calm. Storms were

forecast for later that night, and, in fact, just after the accident the winds began to build. However, the storms never materialized.

Several other boats were in the immediate area. The operator of one of the boats claimed that he tracked this boat right into the breakwall, knowing that the boat would hit it.

The harbor was marked by four lighted aids-to-navigation that could be easily seen if background clutter were not present. However, fishermen with lanterns were on the breakwalls, a lighted municipal parking lot and a well-lighted marina were in the background. This created a clutter of multi-colored lights which made it difficult to distinguish the flashing lights of the navigational aids.

3.0 NARRATIVE OF THE ACCIDENT

The following narrative was formulated from an interview with the owner/operator, the Coast Guard Officer that rescued the occupants and the boat, and the manager of the boat yard that is repairing the boat.

3.1 Pre-Accident

The owner slept until 1130 which is his normal habit since he operates a store that opens at noon. He tended the store until 1700, at which time he closed the store, went home, picked up his family, went to a local restaurant for dinner, and went to the boat. The other guests convened at the boat and they departed for their evening ride at about 1830. They cleared the harbor and proceeded west along the shore to the next harbor inlet, a distance of about 15 miles. They entered the harbor and cruised up the small river as far as a boat of their size could go, turned around, and cruised back out into Lake Michigan. By this time it was dark. The owner opened up both windshields to their wide open position. He always did that while travelling at night to increase his visibility. He proceeded east on the approximate reciprocal of the course he had made earlier that evening. The boat was running on plane with both engines turning 2300 rpm. The night was dark, but the water was relatively flat since there was an off-shore breeze. In all, it was a very pleasant night for boating.

Upon approaching the harbor area, the owner/operator slowed his engines to 1500 rpm. The boat dropped off plane and proceeded at about 6 to 7 mph. The owner, familiar with the harbor, decided to enter it from the west instead of entering it through the channel marked by the lighthouse on one side and a flashing light on the other. The way that the operator chose to enter the harbor is not wrong, nor is it unusual, since there are two openings in the breakwalls. In order to enter the harbor from the way he chose, one must locate the flashing white light on the west end of the breakwall and proceed into the inner harbor on a path between the white light and the shore.

The owner/operator attempted to locate the white light from his position at the helm inside the deckhouse. He couldn't. He mentally computed his distance off shore and thought that his track would lead him between the white light and shore. He then located the red flashing light on the far end of the breakwall and continued to search for the flashing white light on the near end of the breakwall. He told his passengers to look for it. The time was 2145. He was in the middle of attempting to explain the situation to a female guest standing beside him, and his wife standing on the other side of the female guest, when he saw a cement structure about 30 feet in front of him. At that instant, the male guest, who was sitting on the foredeck, jumped up and waved his arms in such a way as to tell the operator to turn to the right. The owner/operator spun the wheel sharply to the right, but it was too late.

3.2 Accident

The boat ran up onto the slanted end of the breakwall and came to rest in a bow up attitude. It then listed to starboard until its starboard chine contacted a large rock just under the water at the end of the breakwall. The sliding door in the cabin rolled shut due to the force of gravity. The owner attempted to open it, but couldn't. He then shut down the engines and instructed everyone to exit the boat through the forward hatch and climb to safety on the breakwall. The people on the foredeck climbed down to the breakwall. He called the Coast Guard on his VHF radiotelephone, and, after communicating with them, exited the boat. Upon exiting the boat, he found that the boat was only about 10 feet away from the white flashing aid-to-navigation that he had been searching for.

He quickly surveyed the boat, found that the starboard aft corner of the cockpit was only inches above the water and decided to tie the boat to the lighthouse to prevent it from sliding back into the water. The Coast Guard came and took everyone aboard their boat except the owner/operator who said that he wouldn't leave his boat alone at night for fear that scavengers would surely strip it by morning. He requested that the Coast Guard find some way to get the boat off of the breakwall before the water got rough due to the storms that were supposed to pass through later that night.

3.3 Post Accident

The Coast Guard personnel took everyone but the owner ashore. The owner boarded his boat and plugged up the cockpit scuppers to attempt to keep as much water as possible out of the cockpit. He then surveyed his running gear and found that the port propeller was out of the water and appeared to be undamaged. He started the starboard engine and attempted to back the boat off. It wouldn't budge. However, he noticed no vibrations and assumed that the starboard running gear was undamaged. He waited for help.

The Coast Guard returned several times and finally came out with two boats with the intention of pulling the stricken vessel off of the breakwall. Bridles were wrapped around the boat in two directions. One rescue boat was positioned directly aft of the stricken vessel while the other was positioned at 90 degrees to port. The boat on the beam pulled first which righted the stricken vessel, then the other rescue boat pulled it off of the breakwall. While backing off of the breakwall, both propellers were damaged as were the rudders, one rudder stuffing box, the shafts and the struts. The owner, who was on board with one Coast Guardsman, checked for leaks and found that the port strut bolts had been pulled out. Water was entering through the strut bolt holes. The owner got some towels, placed them over the strut area and requested that the Coast Guardsman stand on the towel. He did and the leak stopped. The boat was towed to a local marina, where arrangements had been made for immediate hauling. It was now approximately 0600.

The owner/operator had nothing but praise for the Coast Guard. They were on the scene within minutes after the distress call and the ingenious boat rescue operation was considered to be above and beyond the call of duty.

4.0 FACTS FROM THE BOAT INSPECTION

The 1972 boat was a well designed and built fiberglass powerboat. Designed as a sports cruiser with deep-v hull, it had sleeping accommodations for six, a galley, dinette, head, and salon area. The control station was located in the salon on the port main bulkhead. A fishing cockpit was aft, accessible through a sliding glass door. A flying bridge was not installed. The hull was hard chined and of warped plane configuration with a deep forefoot and very shallow vee bottom aft. The boat was powered with twin inboard gas engines with 470 combined horsepower. Manufacturer's literature shows the length to be 31' 0", beam 11' 3-1/8", draft 27-3/4", and the displacement 11,000 pounds.

Most of the damage was in the process of being repaired when the boat was inspected. A one foot section of the stem just below the waterline was damaged. The fiberglass laminate was crushed, but did not open up. The crushed material had been ground away and a patch had been installed. Several nicks and scratches had been ground down on the hull bottom and chine, and were awaiting patches. The shafts had been pulled, new struts, propellers and one new rudder and stuffing box obtained. Hull damage around the port strut and rudder stuffing box had been repaired.

The boat sustained surprisingly little damage. This may be due to the rugged hull construction techniques used by this manufacturer.

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

This seems to be a case of operator disorientation as well as questionable effectiveness of our present aids-to-navigation system.

First, the operator mentally positioned himself several hundred feet closer to shore than he actually was. With this in mind, it is possible that he was visually searching in the wrong direction for the white flashing light marking the near end of the breakwall. Considering that there were so many lights in the background, it would have been quite difficult for the operator and his guests who were also searching for the light, probably in the direction that the operator was looking, to see the light which flashes for a one second interval every four seconds.

When he was very close to the light, the operator couldn't see it because of the long overhang of the cabin top. The light was above him. This does not explain why the two people on the foredeck didn't see it.

During the first phone call to the owner, his brother was contacted and said that the light was out. In fact, he said that it was out for several minutes after the boat hit the breakwall. It then resumed its normal flashing pattern. His brother was not on board at the time. Later, when the operator was contacted by phone, he said that the flashing light was aligned with the light house and, therefore, was not visible. However, during the interview, he drew his probable course on a chart as well as the one he thought that he was on. No mention was made of the alignment problem and the courses were not drawn parallel to a line through the two lights. Apparently, he had been thinking about the accident situation and discounted the possibilities that the light was out or placed in a position where it could be obscured by the lighthouse. He had realized that he was at fault, not the light, and admitted to having made a judgment error concerning his distance off shore.

But in defense of the operator, as well as the many others who have made navigational errors while entering inlets, the present flashing aids to navigation do tend to blend into the brightly lit harbor backgrounds found at most of the inlets making the identification of the aids to navigation quite difficult, if not sometimes impossible. This will be discussed further in Section 7.0.

It is interesting to note that the bow watch motioned to the operator to turn right. He responded by spinning the wheel to starboard. But he was going slow. That boat manufacturer installs very small rudders, which work well at high speed when the propellers are thrusting plenty of water past them, but are relatively ineffective at displacement speeds. If the operator would have known that and would have pulled the shift levers into reverse and advanced the throttles instead of attempting to turn, the collision could have possibly been avoided and probably, even if the boat would have hit the breakwall, the damage would have been less.

6.0 PROBABLE CAUSE OF THE COLLISION

The operator misjudged his position, thinking that he was several hundred feet closer to shore than he actually was. Instead of stopping when he couldn't locate the light that marked the near end of a concrete breakwall, he continued towards the harbor and ultimately collided with the end of the breakwall.

7.0 DYNAMICS/ANALYSIS OF THE ACCIDENT

In order to avoid this type of accident, boat operators should be taught to stop whenever the perceived situation is not totally clear and understandable. In this case the collision could have easily been avoided by utilizing such a technique.

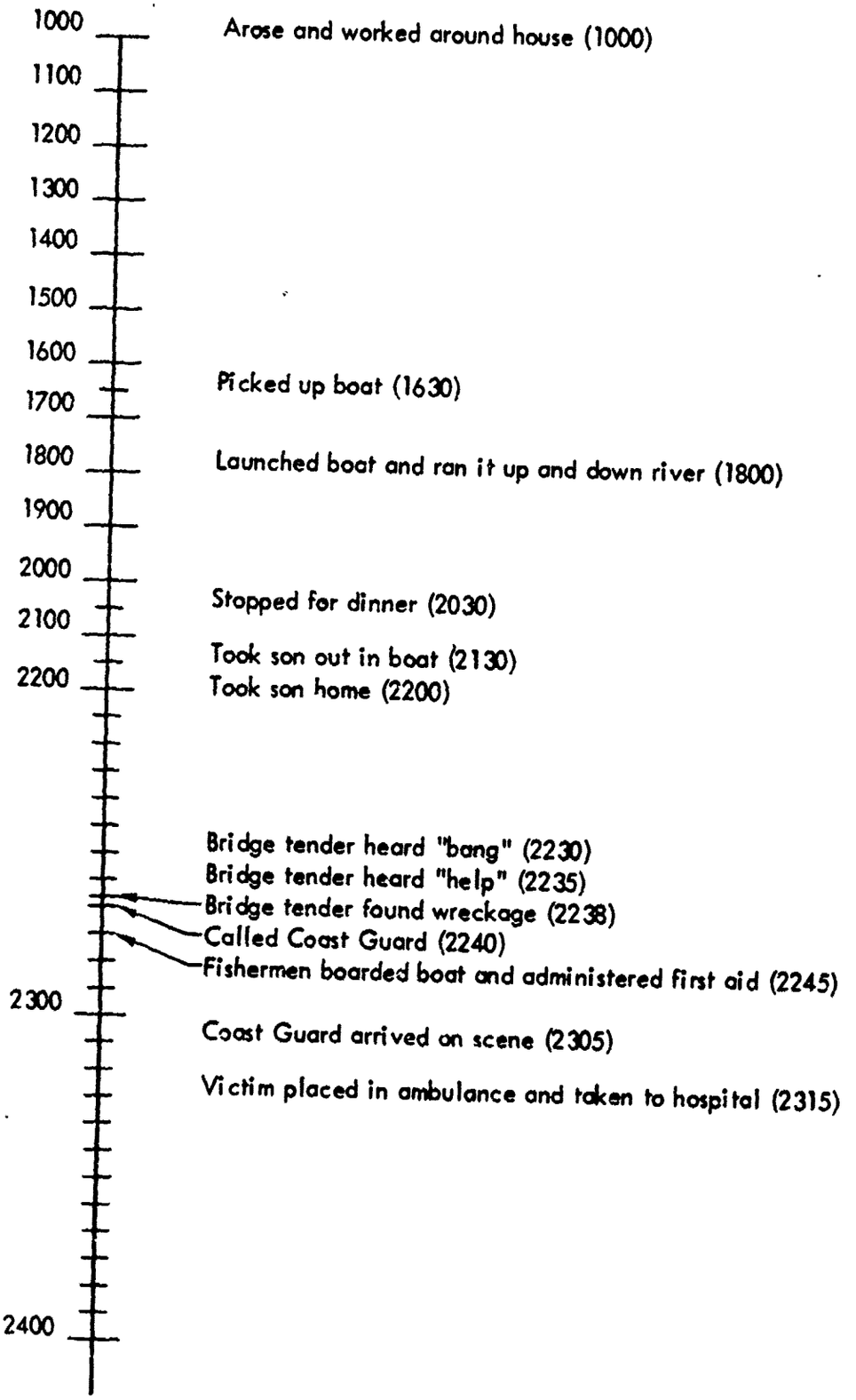
Additionally, harbor charts should show a picture or sketch of what the light configurations should look like when approached from the proper angle. The "Yachtsman's Guide to the Bahamas" has used this technique for years with great success (see Figure 2).

Thought should also be given to making a study of the adequacy of the present system of lighted aids-to-navigation. Perhaps background clutter has become so dense that our aids are no longer adequate.

The marina manager, also a licensed charter fishing captain, said that many boaters on the east side of Lake Michigan run upon the south breakwalls because they locate the main white light that marks the outer port side of the inlet, then look for a red light to starboard. If they are approaching from the south, the red light is aligned with the white light and is not seen because they aren't looking for it there. The second red light is spotted and assumed to be the one marking the end of starboard breakwall. They proceed towards a spot between the two lights and hit the breakwall. (See Figure 3.) This type of accident can be avoided by making the outer red light significantly different in appearance from the inner red light.

Suggestions have been made concerning the use of high intensity quick flashing lights similar to those used to mark airport runways and aircraft at night. If the first two lighted aids at each inlet were of this type, they may provide a more visible target to shoot for. This accident might have been avoided as well as at least half a dozen similar ones that were reported this year if the operator had been sure of his position relative to the entrance of the inlet.

TABLE I. TIME LINE OF EVENTS IN THE ACCIDENT



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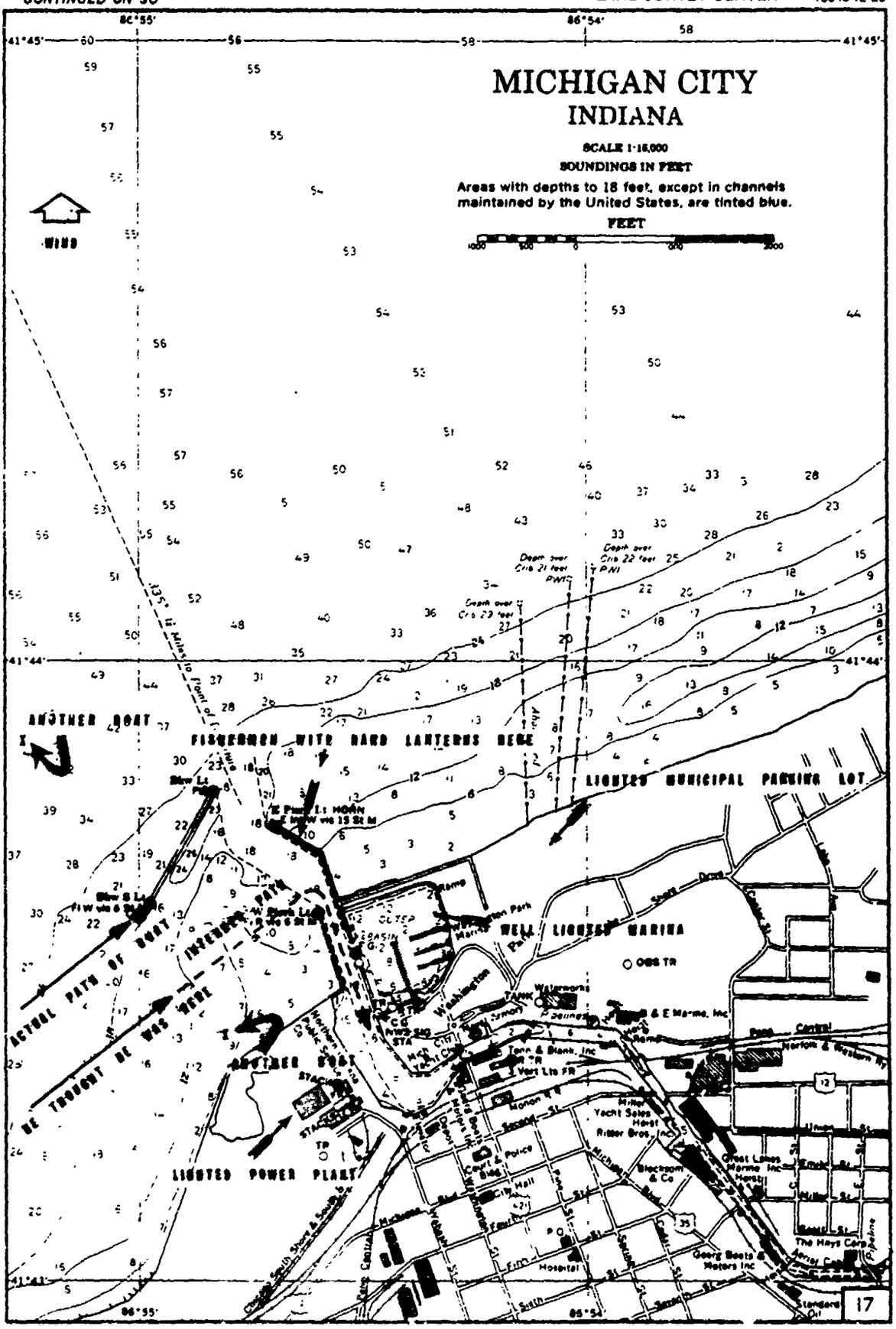


Figure 1. Collision Area Diagram

-78-

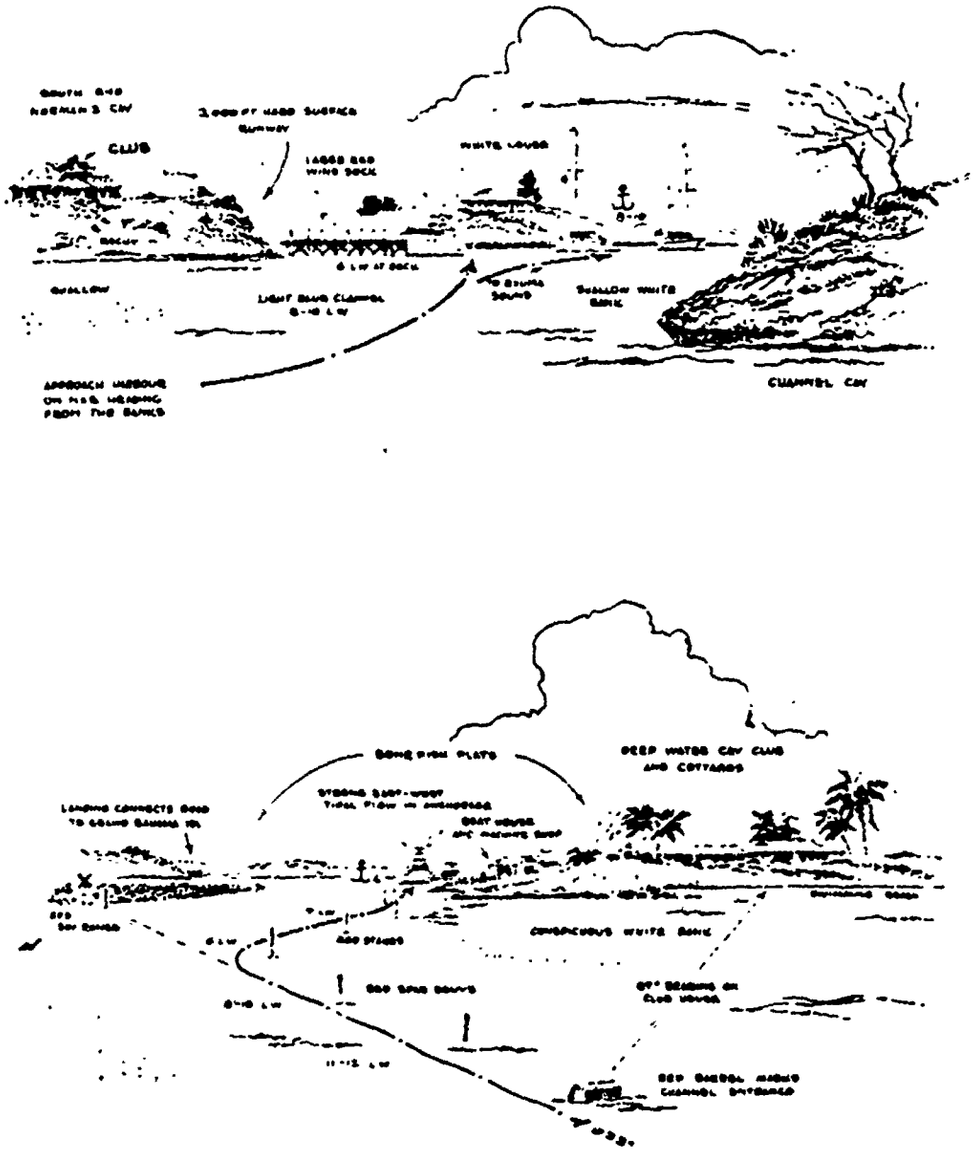


Figure 2. Example of Sketch (or Photograph) Technique to Show Configuration of Prominent Landmarks when Entering Inlets or Harbors (from "Yachtsman's Guide to the Bahamas")

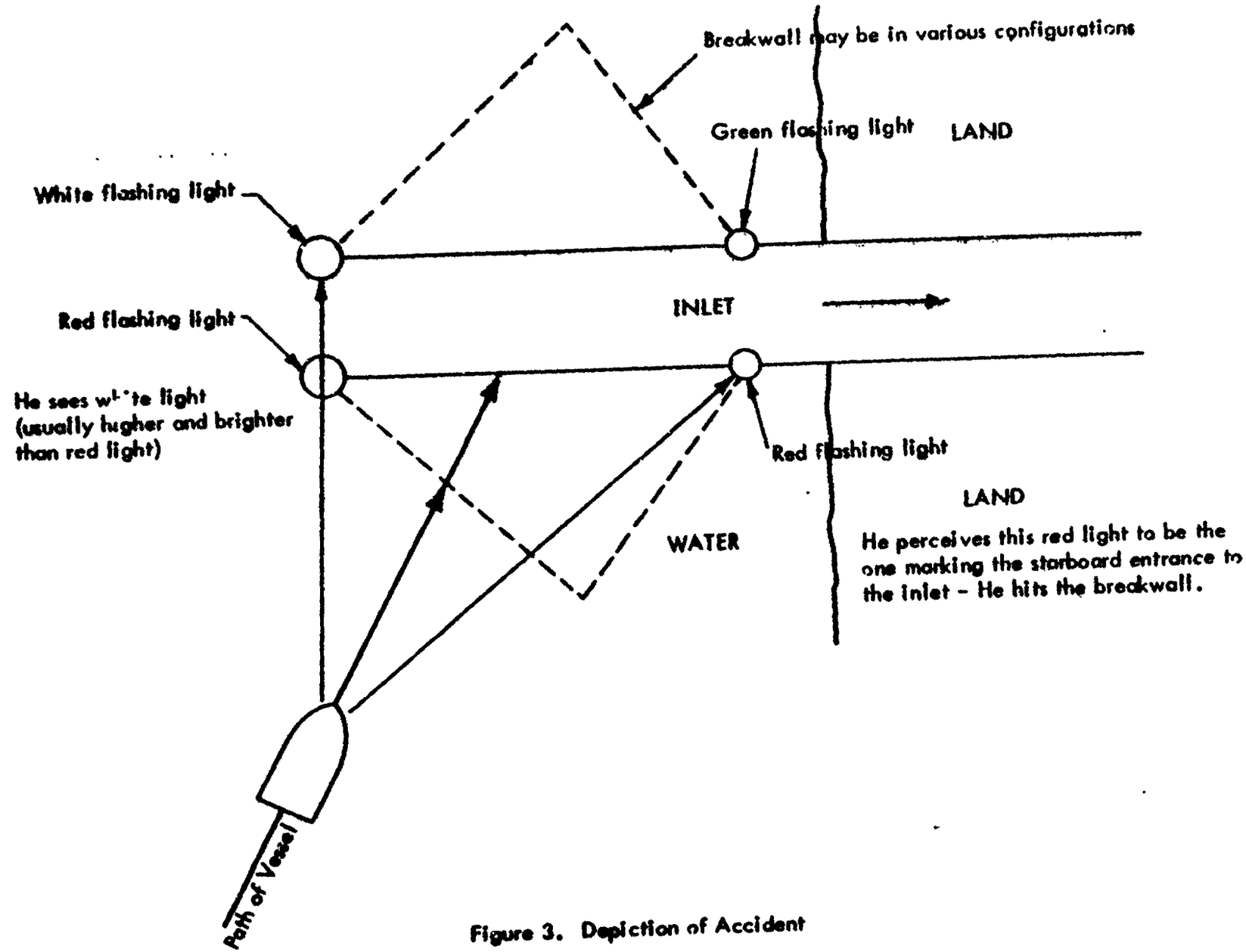


Figure 3. Depiction of Accident

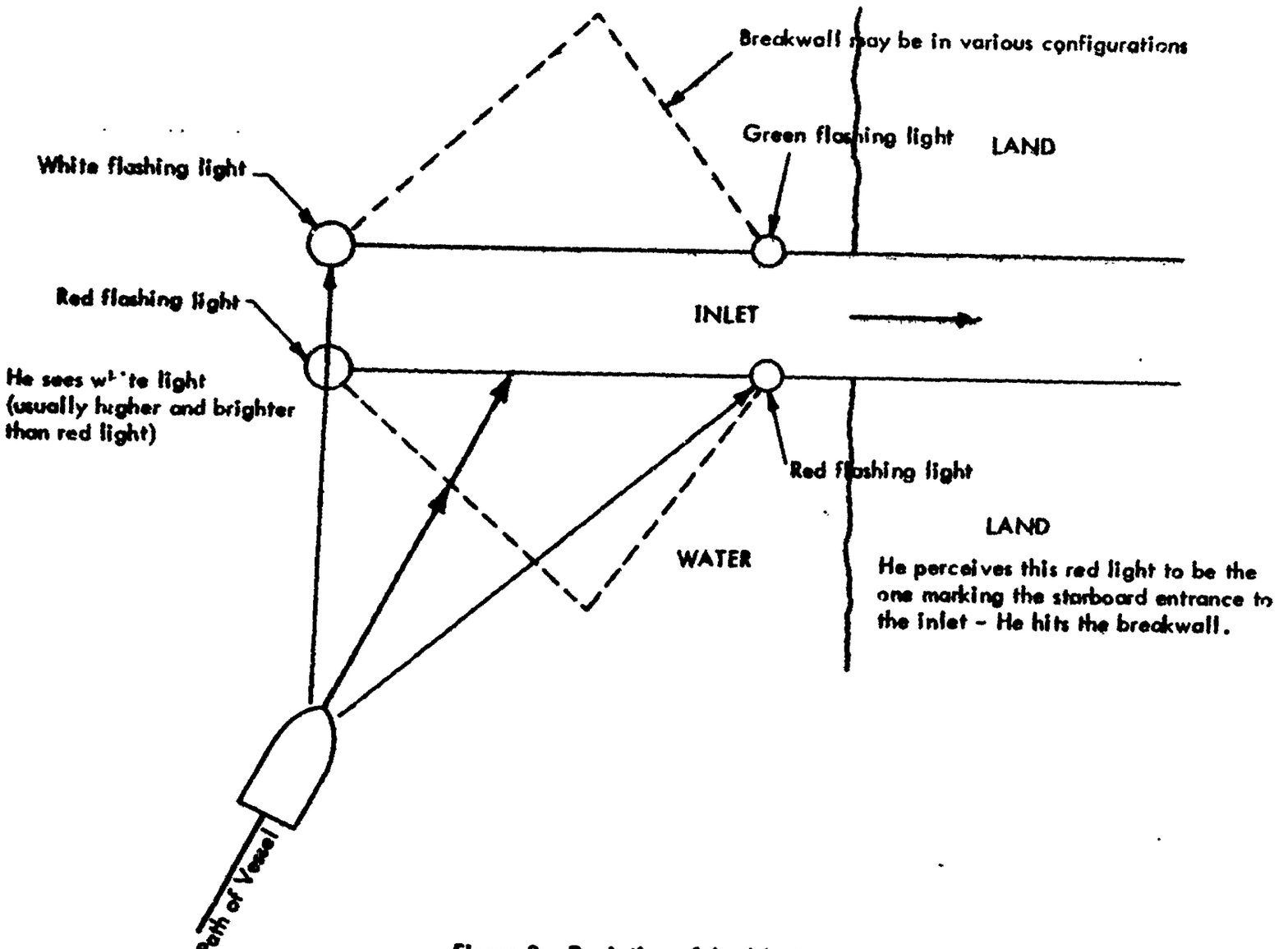


Figure 3. Depiction of Accident

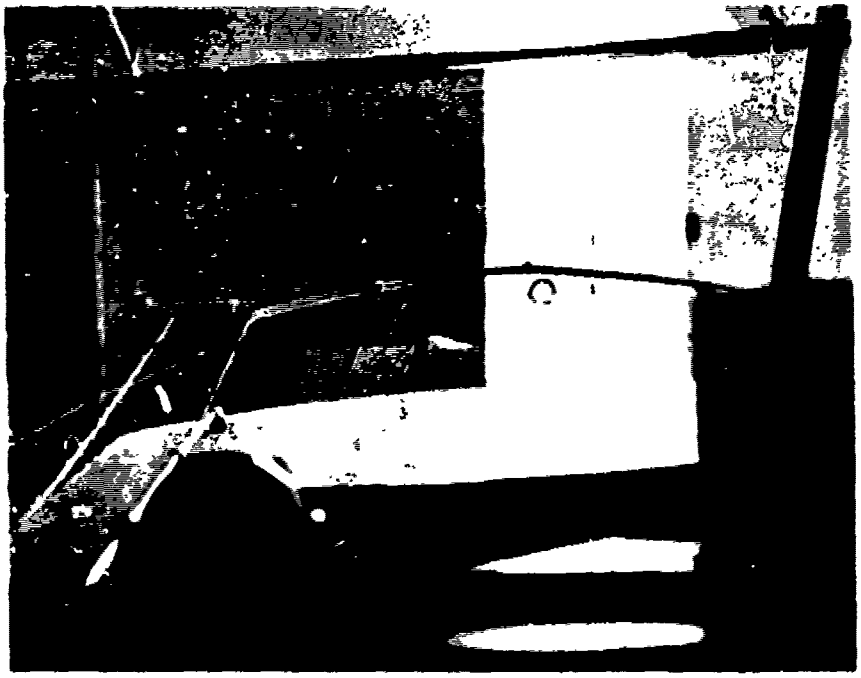


Figure 5. (Top) - Control Console
(Bottom) - Visibility From Helm (Note Windshield in Up Position)

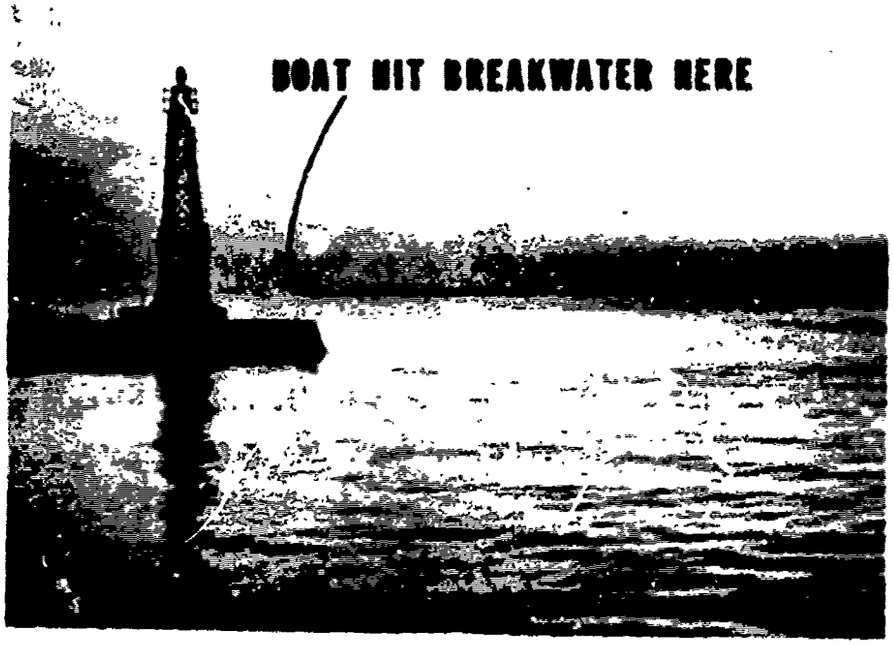


Figure 6. (Top) - Breakwater at Dusk
(Bottom) - Breakwater - Inner Red Light In Foreground

ACCIDENT INVESTIGATION REPORT

Dates of Investigation: 21 & 22 July 1975

Date of Accident: 16 July 1975

Investigation: Collision No. 75-05

SUMMARY — WYLE ACCIDENT NO. 75-359

Two sailboats, a 30 ft cruising sailboat and a 12 ft day sailer, were sailing to windward on opposite tacks on a small lake. They were on collision courses. Neither operator saw the other boat because their sails were obscuring their view. They ultimately collided with each other.

The weather was clear, the wind was brisk. In general, it was a perfect day for a sail.

The 30 ft boat on starboard tack hit the 12 ft boat broadside and capsized the 12 ft boat. The operator of the 12 ft boat sustained a minor facial laceration. His boat sustained some fiberglass damage, a frayed shroud and a bent mast. The 30 ft sailboat sustained minor gelcoat scratches.

1.0 BOAT OCCUPANT DATA

30 ft Sailboat

Operator/ Passenger	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD's Worn
Operator	F	28	135	Fair to good	Over 500 hrs	C.G.Aux	No
Passenger	M	28	150	Excellent	Over 500 hrs	C.G.Aux	No

This couple are married and have no children. He manages a large tire and appliance store and she teaches school. They live in a nice house in an upper middle class section of town. He has owned sailboats for many years. He also had much powerboat experience, including boat handling experience during his four year hitch in the Coast Guard. She is a recent convert from powerboating with her parents. She has been sailing for two years. They both entered the C.G. Auxiliary boating safety course but never completed it. It was aimed at powerboats and they lost interest.

12 ft Sailboat

Operator	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD's Worn
Operator	M	15	155	Excellent, holds junior lifesaving certificate	5 yrs - mostly sailing	No	No

The operator was a very nice young man from an upper middle class family. He was intelligent and very co-operative. His grandfather owns a large racer-cruiser type sailboat and campaigns it in many of the Great Lakes races. This operator works as foredeck crew for his grandfather and obviously loves to sail. He was knowledgable of the boat, its parts, sailing, and appeared to know the rules of the road.

2.0 ENVIRONMENT

The day was sunny, the temperature was in the 80's, the wind was out of the southwest at about 15 mph and there was about a 6 inch chop on the small lake just inside the inlet to Lake Michigan.

Several other boats were in the immediate vicinity, in fact one other 12 ft boat just missed colliding with the 30 ft boat.

3.0 NARRATIVE OF THE ACCIDENT

The following narrative was formulated from interviews with the operator of the 12 ft sailboat, the operator and passenger of the 30 ft sailboat, and the local Coast Guard representative.

3.1 Pre-Accident

3.1.1 30 ft Sailboat

The operator got up late because it was her day off. She did some furniture refinishing around the house while she waited for her husband to return from work. He worked from 0800 to 1200 that day. They ate lunch, did some errands and arrived at the boat at about 1430 in the afternoon. They cleared the marina entrance under power, shut off the engine and began to tack down the lake towards the inlet (or outlet) to Lake Michigan. They only have two sails, a mainsail and a 130 percent overlapping genoa. When they are close hauled, the genoa is sheeted inside the life lines and sweeps the deck. There is no way of seeing forward under the genoa. The operator was seated to port, her husband to starboard in the cockpit. Just prior to the collision, they were on starboard tack. The genoa was to port directly in front of the operator.

3.1.2 12 ft Sailboat

The operator of the 12 ft boat played kickball in the morning. He ran the rescue boat in the early part of the afternoon for a ladies race at the sailing club and decided to go sailing with two of his friends. While still in the rescue runabout, he picked up his boat off the beach at the sailing club and towed it to his friends' house about two blocks away and on the waterfront directly across the street from his house. This was done so that he wouldn't have to carry his sails from his house to the sailing club.

He returned the runabout to the sailing club, came back to his friends' house, rigged his boat while his friends rigged theirs and took off on a port tack across the lake.

It was a brisk wind for a 12 ft sailboat. In order to keep it upright, he had to hike out. Since the boat was not equipped with hiking straps, he hooked his left foot under the forward thwart.

The boat did not have a hiking stick on the tiller, so he put his right foot over the tiller and steered with his ankle. The jib sheet was cleated to leeward and he held the mainsheet with both hands. He was not wearing a PFD, but had two in the boat.

His friends were both much lighter than he was and in fact, together weighed about as much as he did. They were also hiked out and were to leeward and ahead of him as they approached the middle of the lake.

His jib was cut low and didn't have a window in it. The boom was also quite low. He couldn't see under it.

3.2 Accident

The 30 ft boat was on starboard tack and on a collision course with both 12 ft boats which were on port tack. The operator of the 30 ft boat saw the 12 ft boat with the two boys in it just as it approached the port side of her boat on a collision course. The rules of the road state that the starboard tack boat should hold course and speed; however, in an attempt to avoid a collision with the first 12 ft boat, she turned upwind. Apparently, the boys saw her at the same instant and bore off to pass behind the larger boat. Just as the little boat was passing behind her boat, she saw the sails of the other 12 ft boat directly in front of her. She again turned upwind, but it was too late. The two boats collided. The bow of the 30 ft sailboat hit the starboard side of the 12 ft boat.

The boy never did see the 30 ft sailboat prior to the collision. In fact, the impact was so light that he never felt it. According to him, the boat suddenly capsized to windward. It wasn't until after he surfaced that he saw the larger boat and knew that a collision had occurred.

The capsized boat passed alongside of the port side of the larger boat. The mast was out of the boat and was bent. The boy was swimming beside the boat and appeared to be unhurt. Aboard the 30 ft boat, the husband took the helm and kept the boat headed to windward while the wife quickly lowered the genoa. They then started the engine and called the Coast Guard on their VHF radio telephone. They circled the 12 ft boat until the Coast Guard came on the scene.

Meanwhile, the boy was swimming in the water, without a PFD, and was attempting to straighten out the rigging which was lying on the surface. He righted the boat, took the jib off of the forestay, and wrapped the mainsail around the mast. He then asked his friends to sail back to their house and get their father's runabout to use as a tow boat.

3.3 Post Accident

Since the collision happened within a few hundred feet of the Coast Guard Station, they were on the scene within minutes after the mishap. After questioning the occupants of the 30 ft boat, the Coast Guard allowed them to go. They returned to their marina. They boy didn't want the Coast Guard to tow his boat. He preferred to tow it, using his friends' runabout. He towed the boat to the Coast Guard Station where it was pumped dry. He then towed it across the lake to the sailing club.

The boy received a minor laceration on his forehead and cheek. It appeared that a shroud hit him in the face at the moment of impact.

4.0 FACTS FROM THE BOAT INSPECTIONS

4.1 30 ft Sailboat

This was a fairly new boat of a recent design. The boat was intended to be used as an off-shore racer/cruiser. The cockpit and helm is located all the way aft but visibility over the bow was good for this size sailboat since the cabin structure was very low. The present owners don't race the boat. They only use it for cruising.

The boat is 29'11" long, has a 9'6" beam, a draft of 5'3" and weighs 8,000 lbs. Rated sail area is 399 square feet.

Damage as a result of the collision included an abrasion in the gelcoat on the stem just above the waterline. The scratches were only a few thousandths deep and could easily be removed with some wet sanding and polishing.

4.2 12 ft Sailboat

This boat is a small one-design class boat of the type that has been used as junior training boats by many yacht and sailing clubs throughout the country. It is lightweight, inexpensive, is fairly stable, and is a fairly good performer. The local sailing club had a fleet of these boats. The kids raced them throughout the summer.

The boat is actually 12'4" long, has a 5' beam, draws 5" with the centerboard up, weighs 285 lb, and has 90 ft of sail area.

Impact occurred at two places. The first impact was between the stainless steel bow pulpit on the 30 ft sailboat and the starboard shroud of the 12 ft boat. The pulpit hit the shroud about 5'10" above the waterline or about in the middle of the shroud. The 1/8" stainless steel shroud was displaced and actually frayed at the point of impact. The associated compression load on the mast caused it to buckle. Minor scratches on the mast in the vicinity of the bend indicate that the bow pulpit may have made contact with the mast also.

The stem of the 30 ft boat also made contact with the starboard gunwale of the 12 ft boat abeam of the mast and just forward of the thwart. The gunwale collapsed. The fiberglass hull ripped open for about 7 in. below the gunwale, but returned to its natural shape after the impact, leaving only a crescent shaped crack showing. All hull damage was above the waterline. The fiberglass deck and coaming structure was also damaged. The owner intends to secure the services of a local fiberglass expert to patch the hull and deck.

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

Both operators were blinded by their sails. In the case of the 30 ft sailboat, the deck sweeping 130 percent genoa extended from the stemhead along the port gunwale to a position about 1/2 of the boat length aft of the stem. Visibility was obscured in this area.

Both the jib and the mainsail obscured the visibility of the 12 ft boat operator. In addition, a good portion of his attention was taken up by the balancing and steering tasks as he hiked out over the weather gunwale. He had to hike to windward to keep the boat upright. The boat didn't have hiking straps, so he had to hook his foot under the thwart to keep him from

falling overboard. When hiked, he couldn't reach the tiller so he hooked his right ankle over the end of the tiller and steered by bending his knee. Both hands held the mainsheet and in fact, it was the mainsheet that kept him from falling out of the boat. So much of his effort was spent balancing and steering that he probably spent very little effort in looking where he was going. In fact, he was stuck in one position. He couldn't move forward to look around the jib because he couldn't take his foot off the tiller. He couldn't move aft to look behind the mainsail, because he would fall out of the boat if he took his foot out from under the thwart. He couldn't move into the boat and look under the boom, because the shift in weight would cause the boat to capsize.

He depended on other people seeing him and avoiding a collision with him. In addition, the operator of the 12 ft boat was fatigued. He had been exercising in the sun for over 5 hours. Th ults of recent studies show a significant decrease in boat operator performance after being exposed to sun, glare, vibration, noise, etc. for a three hour period. Therefore, we can assume that he may have made less of an effort to see around or under his sails at this particular time because of his level of fatigue.

However, the operator and passenger of the 30 ft sailboat were able to move about at will and were relatively rested. The operator could have leaned back and looked around the outside of the genoa. The passenger could have gone forward and surveyed the area ahead from time to time. If the operator would have coordinated leaning back and looking forward with a quick turn to windward from time to time, she would probably have seen the small boat and could have avoided the collision.

But she was closehauled on starboard tack, and, therefore, had right-of-way over all other boats power or sail. Knowing that one has the right-of-way over all others can sometimes lead to complacency or at least the secure feeling that everyone else will get out of your way.

6.0 PROBABLE CAUSE OF COLLISION

Both operators were inattentive. They were not making the effort to check the water area that was obscured by their sails. The small boat operator would have had to tack or risk capsizing his boat to see that area of water behind his sails. The large boat operator could have checked her obscured area without tacking or endangering the safety of her boat, but didn't.

7.0 DYNAMICS/ANALYSIS OF THE ACCIDENT

The boats were moving relatively slow. Closing speed was in the neighborhood of 5 miles per hour. Neither operator actually felt the impact because the initial impact was between the large boat's bow pulpit and the small boat's shroud, which deflected when hit. The small boat then rotated to port until its gunwale contacted the big boat's stem. The 12 ft sailboat was then pushed sideways through the water. Because the point of impact was forward of the center of lateral resistance of the hull, the 12 ft boat rotated in a counterclockwise direction as it capsized, and, therefore, allowed the large boat to pass by it to starboard.

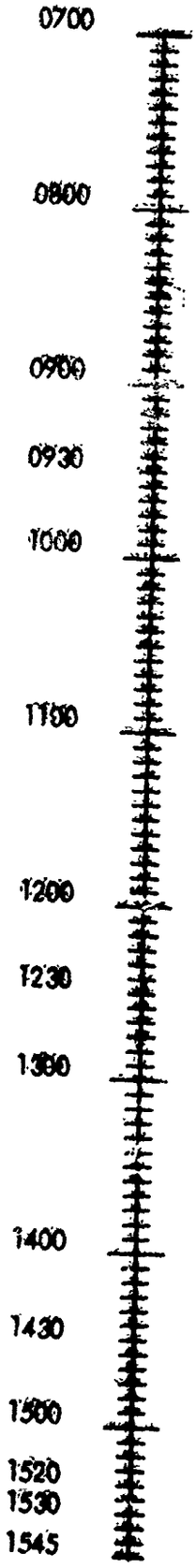
Although this is the first sailboat accident that has been investigated under this research contract, many have been reported through the WATS line reporting system. Many of them occurred because the operators didn't see the object that they hit due to the fact that the sail obstructed their view. During 1974, three of the four sailboat collisions were due to sails obstructing the view. So far in 1975, four of thirteen sailboat collisions have been caused by sail obstructions.

The problem has been discussed in detail in "Recreational Boating Safety Collsion Research, Phase I, Volume I," Wyle Laboratories, June 1975.

Solutions to the problem are varied and include:

- Educational programs - make sure sailors are aware of the problem area and the consequences.
- Regulations specifying clear "windows" in sails.
- Regulations specifying some gap between the deck and the bottom of sails to enable the operator to see under them.

TABLE I. TIME LINE OF EVENTS IN THE ACCIDENT



0700	12' operator awoke
0800	
0900	30' operator awoke and did woodworking during morning
0930	12' operator played kickball
1000	
1100	
1200	30' operator ate lunch
1230	12' operator ran rescue boat for sailboat race
1300	
1400	
1430	30' sailboat left marina
1500	
1520	12' sailboat left beach
1530	Collision occurred
1545	Coast Guard on scene

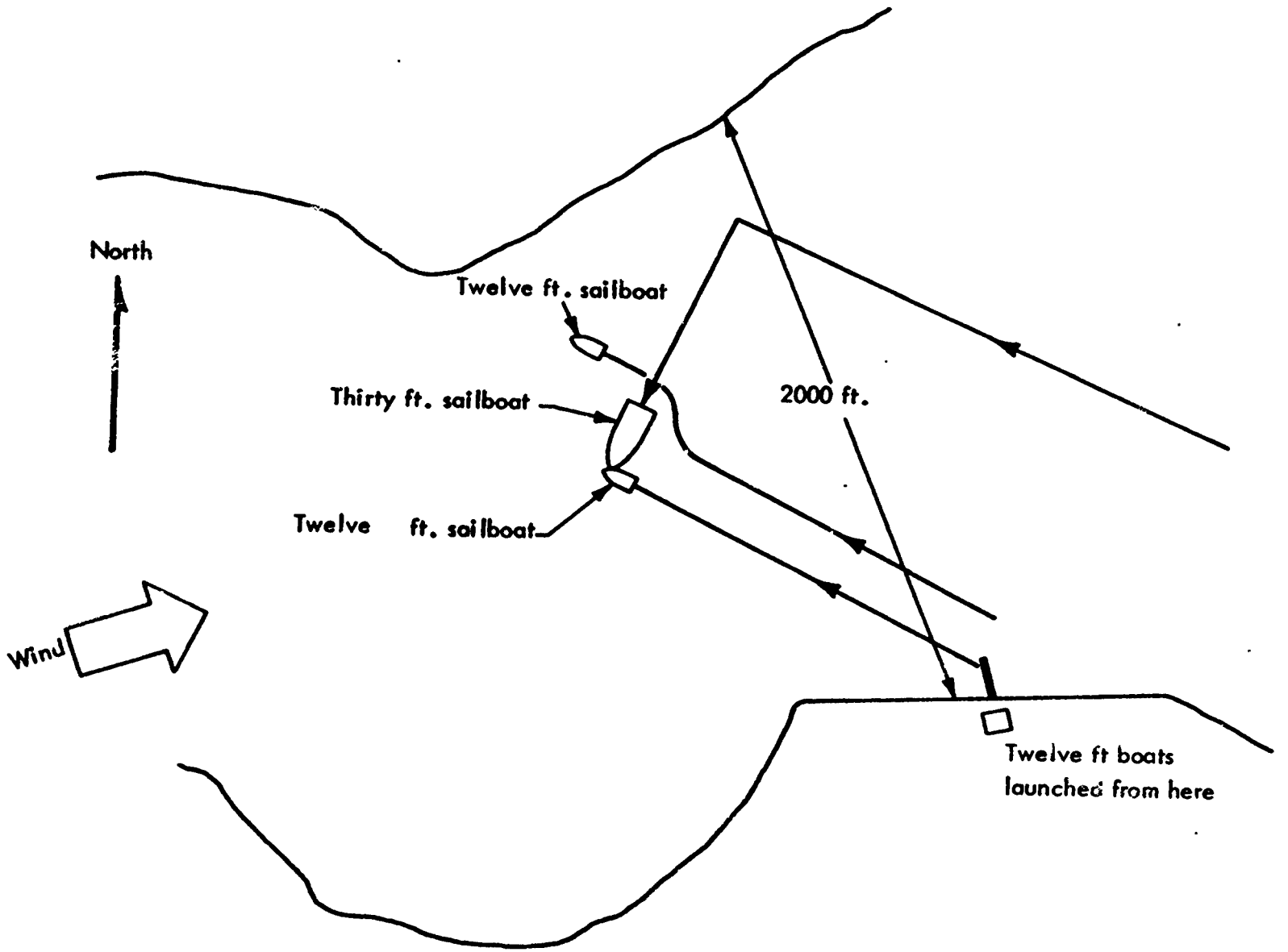
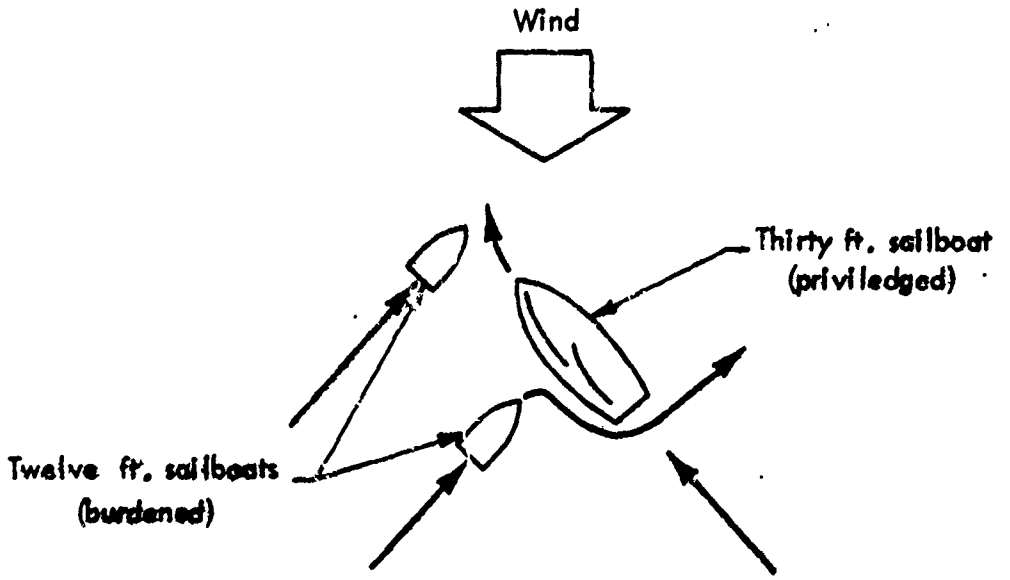
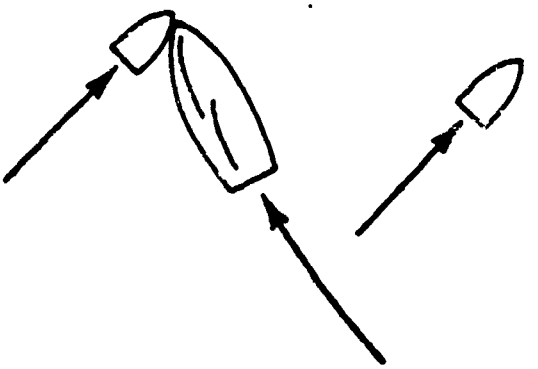


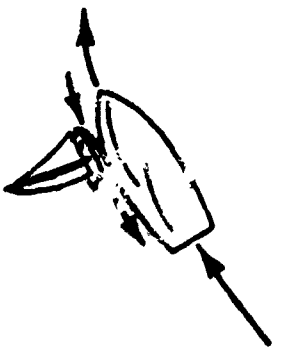
Figure 1. Collision Area Diagram



First twelve ft sailboat passed "under" the thirty ft boat.



Thirty ft boat "headed up" and hit second twelve ft boat.



Twelve ft boat capsized and slid along port side of thirty ft boat.

Figure 2. Accident Scenario

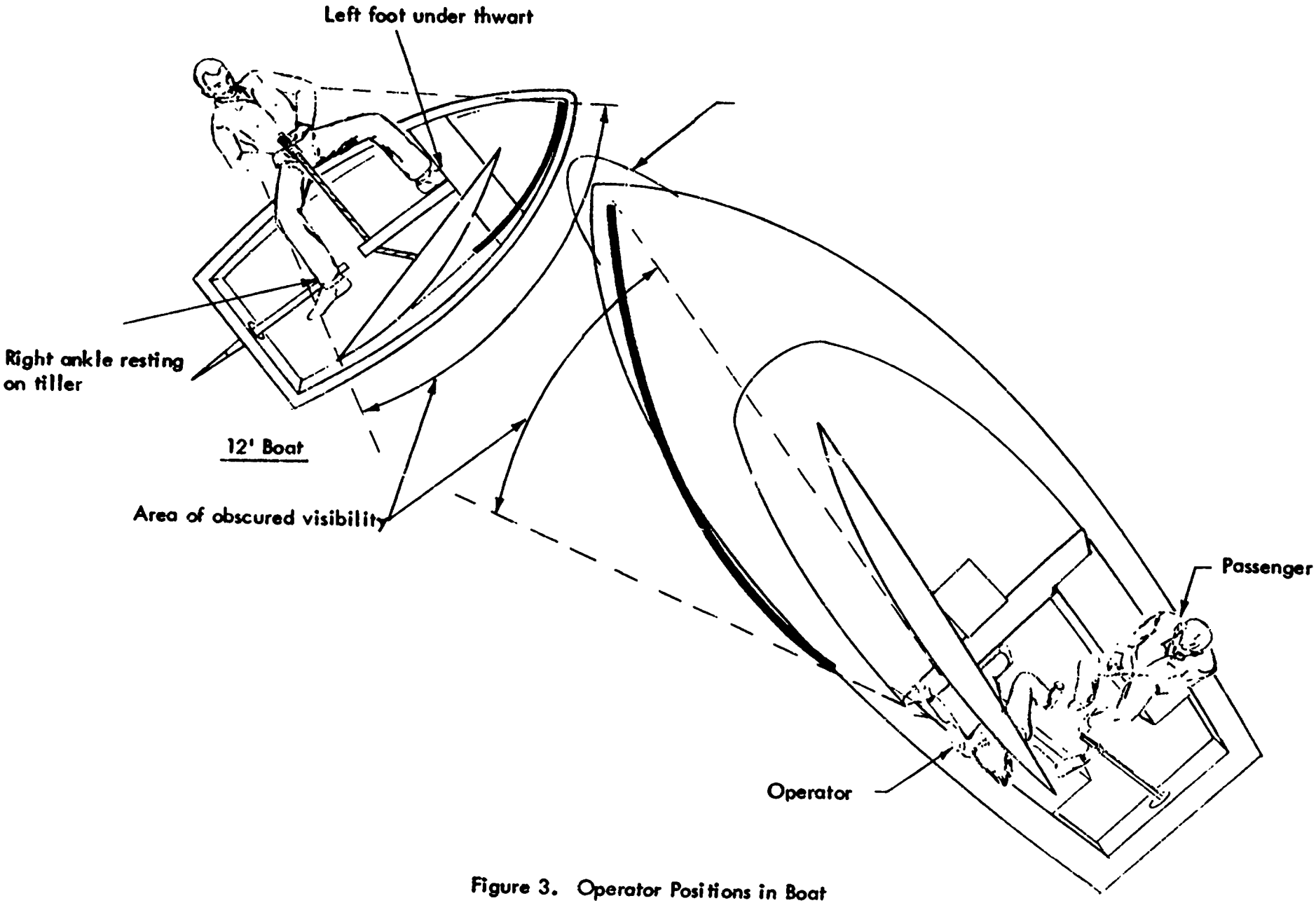
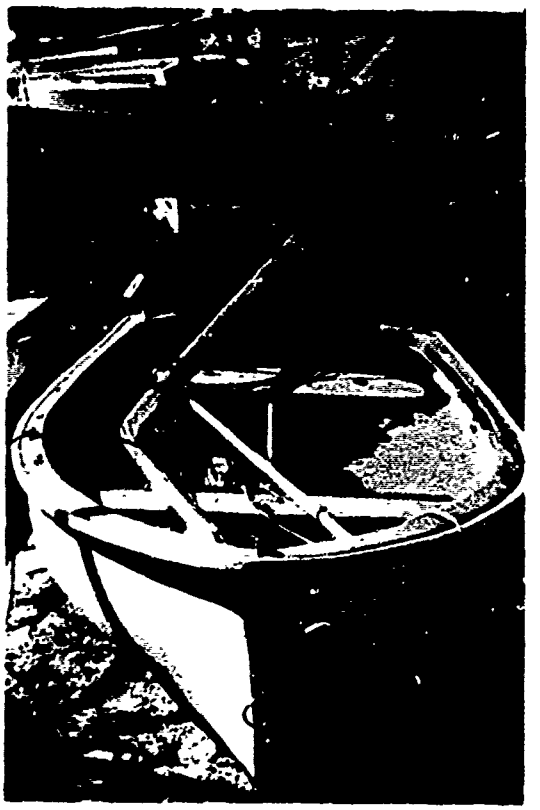


Figure 3. Operator Positions in Boat



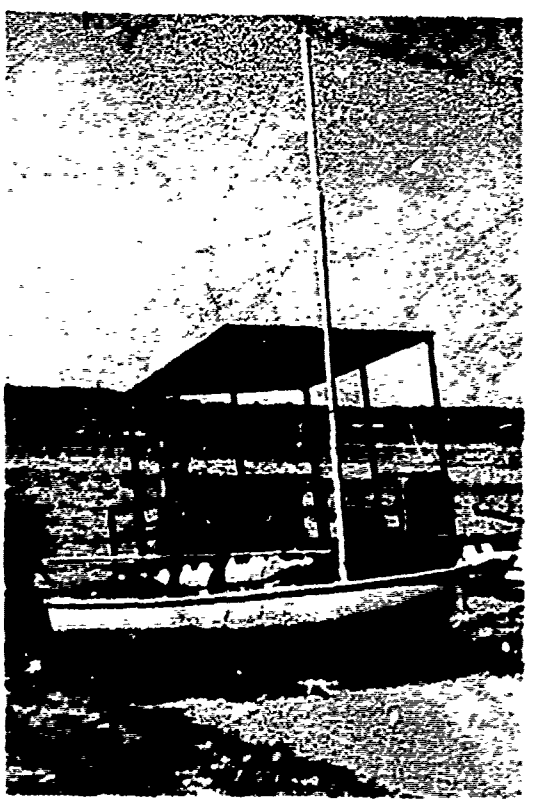


Figure 4. (Top) - Damaged Boat Showing Bent Mast
(Bottom) - Sistership to Damaged Sailboat

Figure 5. Damage to 12' Sailboat

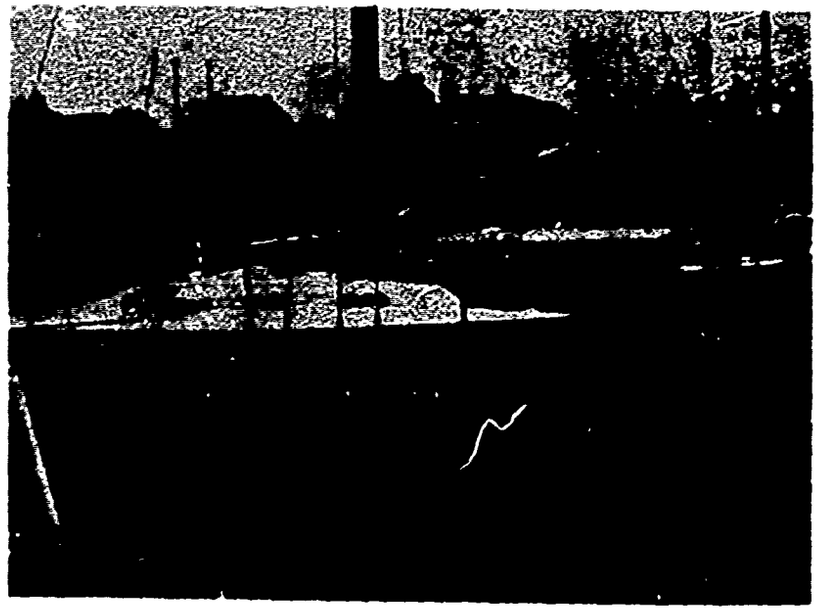


Figure 6. Thirty Foot Sailboat (Note Bow Pulpit)

ACCIDENT INVESTIGATION REPORT

Dates of Investigation: 30 June 1975 & 1 July 1975

Date of Accident: 22 June 1975

Investigation: Collision No. 75-06

SUMMARY — WYLE ACCIDENT 75-235

Late in the afternoon of June 21, 1975, one adult male and one adult female left the harbor of Holland, Michigan, in a 23 ft sport cruiser. The couple were taking out a new boat to "check it out" and were planning to camp somewhere north of Holland. At approximately 0100 on June 22, 1975, the operator put into a port that he thought was north of Ludington, possibly Manistee, according to the interview. He saw what he thought were channel lights and headed in between them. After travelling a few hundred yards, he suddenly saw a sea wall in front of his boat, could not react in time, and collided with it. He signalled for help with a flashlight and was rescued, along with his passenger, by USCG personnel who had heard the impact and were on their way as the operator signalled.

The operator misidentified the location of the accident, which was actually Ludington. The physical evidence suggests that the operator may have been travelling too fast for the conditions. Human factors (fatigue, poor lighting and cockpit design relative to visibility) and the operator's lack of knowledge of where he was and the characteristics of this harbor were the primary causes of this accident, along with speed.

1.0 BOAT OCCUPANT DATA

Operator/ Passenger	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instruction	PFD's Worn
Operator	M	32	225	Ex.	> 500 hrs	None	No
Passenger	F	20	140	Ex.	< 100 hrs	None	No

The boat operator was a self-employed businessman, owning a franchise in an oil company. He was 32 years old; he said he had "been on the water - lakes - all my life." He had been swimming since he was six and boating since he was eleven. He had had a previous accident in another boat that he never reported. He had run over a shoal in a 17 ft boat on a hazardous day (rain and waves to up eight feet). He boats often with his son (not present on this trip) and girlfriend (the passenger on this occasion). He always makes his son wear a PFD, but does not wear one himself, nor does his girlfriend. He stated that after this collision, they will always wear one. He typically does not check weather forecasts, and did not on this occasion. The female passenger was not available for an interview, so relatively little is known about her except that most of her boating experience was as a passenger on trips with this operator. Both parties drink distilled spirits and don't particularly like beer. It is not uncommon for them to drink on the water, although in this instance, all they had was one-half of one can of beer from a six-pack that the girlfriend brought. The operator had consumed the one-half can of beer over the course of a couple of hours. It is queer that the girlfriend brought beer when neither one of them liked beer. The operator had asked her "if she brought a bottle;" her reply was negative. The USCG rescue team stated that they found no evidence of drinking other than the one-half can of beer.

2.0 ENVIRONMENT

In the interview, the operator referred to the "beautiful weather." It was clear and calm. Sunset was 2129. Visibility was good. The air temperature was 68° F. There were no other boats in the vicinity at the time and the water depth was six feet at the point of impact with the sea wall. There were several harbor light, shore street lights, and parking lot lights on (see Figure 1) that were visible from the vicinity of the breakwater.

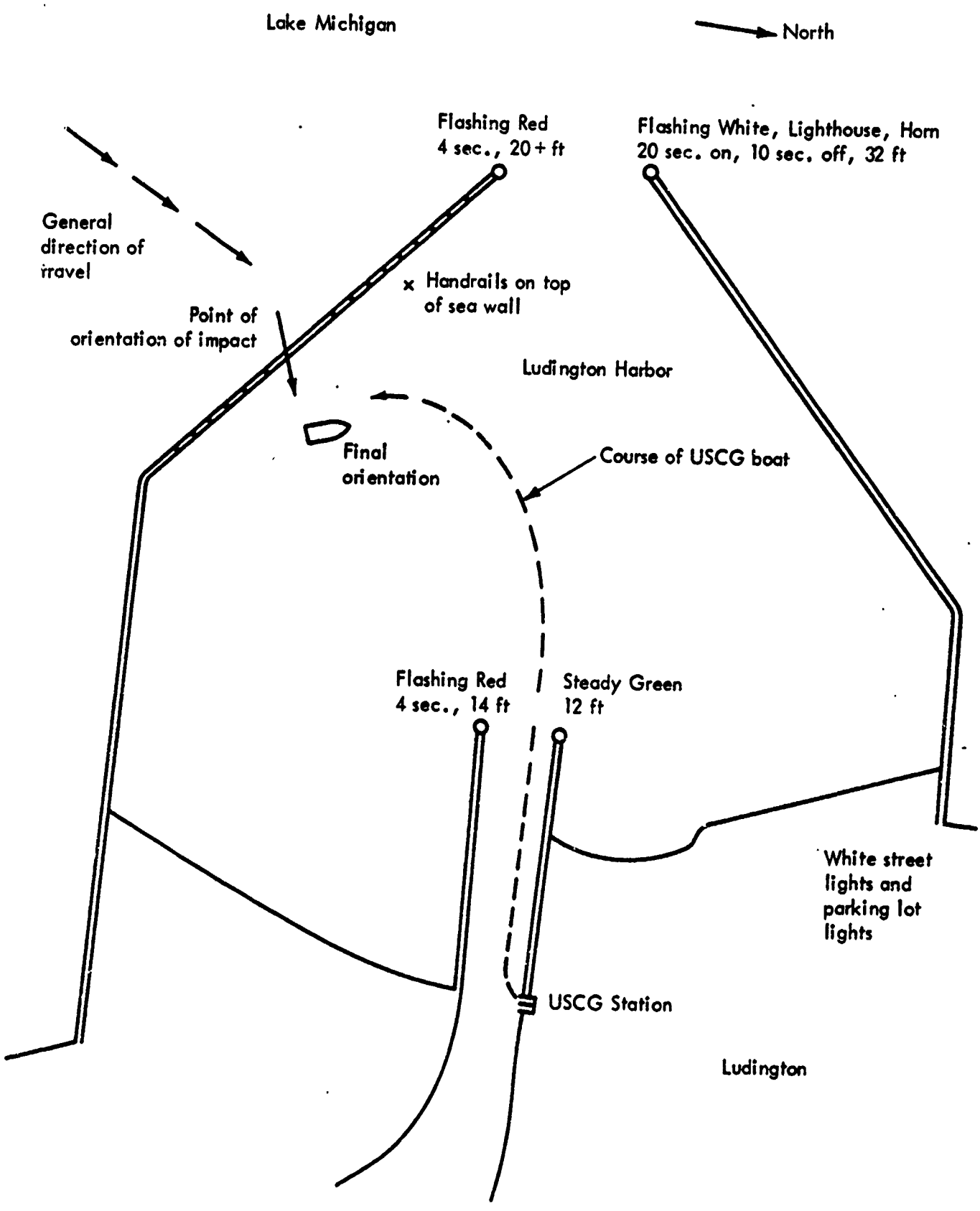


Figure 1. Diagram of Accident Site

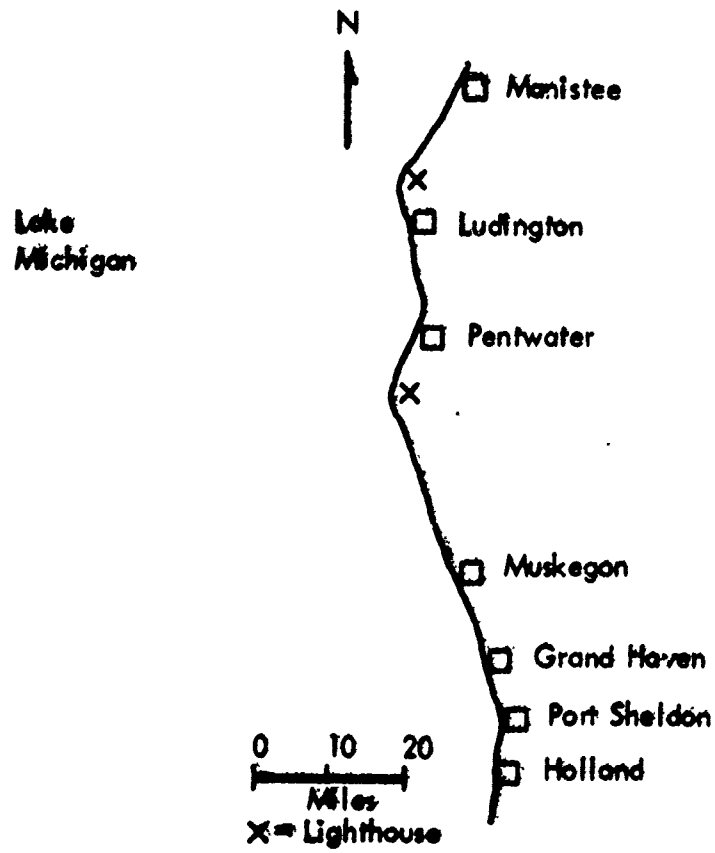
3.0 NARRATIVE OF THE ACCIDENT

3.1 Pre-Accident

On Saturday, June 21, 1975, the operator worked a half-day at his gas station and left around 1300. He went home and got his boat and trailer and returned to the gas station to get fuel. He then picked up his female companion and drove to Holland, Michigan, to launch his boat.

At approximately 1630, the two people left Holland in a new 23 ft sport cruiser to test the boat and determine if it could be used to make a trip across Lake Michigan to Milwaukee. The operator had owned this particular boat for less than one week. The couple planned to camp out overnight somewhere north of Holland after getting a feel for the boat. They proceeded northward along the west coast of Michigan's southern peninsula.

The operator moved the ice chest to the passenger's (female) side of the boat to counterbalance his own weight and noticed that the boat was taking on water while they were out,



so he turned into Port Sheldon to inspect his boat. The problem was found to be a loose clamp on a water hose. The clamp was tightened and the excursion was resumed. The boat still took on some water, but the bilge pump kept up with the problem.

3.2 Accident

At approximately 0045 on June 22, 1975, the operator put in for shore near what he thought was a port north of Ludington. He spotted a white and a green light (probably the interior harbor lights) and headed in between them at 15 to 20 mph and ran over a breakwater. The subject saw the sea wall at the last minute, but did not have time to meditate on the proper reaction. The boat climbed on top of the wall and fell over to the other side.

It was now 0100. The breakwater was the south sea wall for Ludington Harbor, although the operator stated during the interview that he thought the accident had occurred at Manistee, Michigan. The watch at the USCG station at Ludington had spotted the boat and tracked it visually into the sea wall and alerted the USCG personnel. The USCG personnel immediately instituted rescue and recovery operations.

3.3 Post Accident

The operator of the 23 ft craft checked to see that his pump was on (it was), checked for water coming in (there was none), readied life jackets in case they were needed, and checked the condition of his passenger. She had a sore shoulder, but was not severely injured. The operator had a small but deep cut on his arm (cutting edge was unknown). The operator then tried to put his engine in gear as it was still running, but in neutral. The engine would not go into gear, so he began signalling with a red flashlight for help.

The USCG boat came alongside within a couple of minutes and towed the damaged boat to the USCG dock to inspect it.

The operator took a taxi back to Holland to pick up his car and trailer, drove the car and trailer back to Ludington, and picked up his boat. He arrived home in Grand Rapids around 1000 on June 22, 1975.

4.0 FACTS FROM THE BOAT INSPECTION

The boat was a 1975 AMF/Slickcraft Sport Cruiser SS235. The operator was the original owner; the boat had not been on the water before. (See Appendix for interior view of the boat and boat specifications.)

Inspection of the boat at the local dealership, where it was being stored, revealed extensive damage to the bow and numerous scrape marks on the hull near the keel. There also was considerable damage to the stern drive. The large area of damage to the bow (see Figures 2, 3 and 5) was caused by the initial impact. The bow area was caved in, but not punctured. The damage extended well into the layers of fiberglass, but not through. There were scrape marks all along the keel and immediately under the operator's station on the starboard side, but nowhere else on the hull. There are numerous scrape marks on the hull at the transom (see Figure 4), and the housing for the outdrive was cracked. The nameplate for the outdrive was shattered and the arms for the actuators for the power lift were torn from the lower housing. There was some damage to the area of the skeg and the paint in that area was scraped away as if it had been dragged across a hard surface. The steering wheel had been bent at impact and apparently came off its post later. Inspection of an identical model in the dealership showed that the steering wheel was very securely mounted. The dealer and operator claimed that the prop still ran true to its intended axis and there was no evidence of damage to the prop blades. The throttle/shift arm still moved, but the operator was unable to get the boat to respond in forward gear after the collision. Since the stern drive appeared to have suffered a significant impact this could be due to a broken cable, broken shaft, or some other form of impairment. All lights and light switches were still operable.

The locations of occupants and gear are shown in Figure 6. There were plenty of PFD's, although none were being worn. Soon after impact, the operator got a couple of these out of the bow in case they were needed. The lights were operable and consisted of separated red and green mounted on the cockpit sides and combined fore and aft white lights (360° total coverage) on a pole above the windshield. A control switch enabled the operator to have all lights on, or just the windshield white lights, or none. The boat was equipped with a compass which the operator thought was fairly accurate.

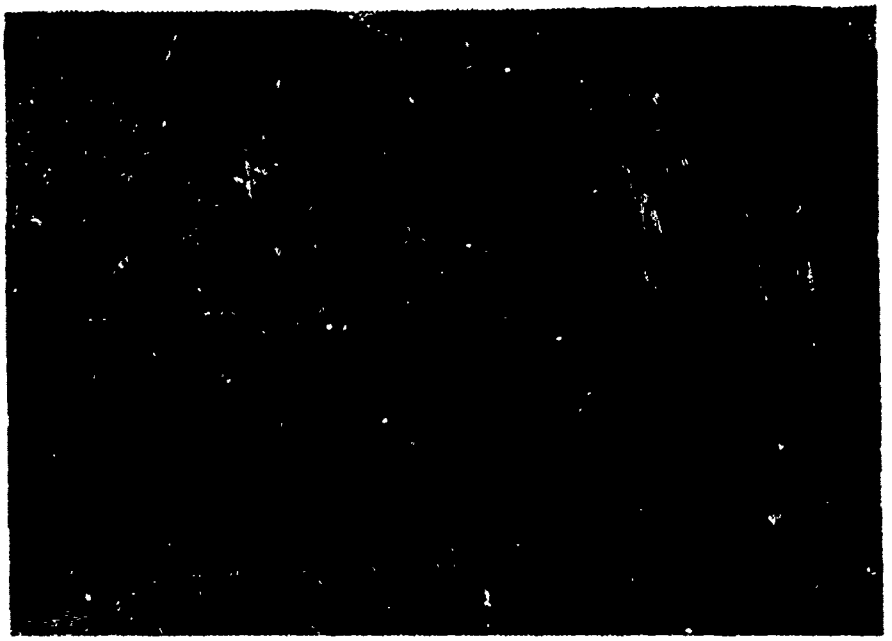


Figure 2. Bow Damage

Figure 3. Hull Viewed From Operator's Side

Figure 4. Transom Damage and Stern Drive

Figure 5. Bow View

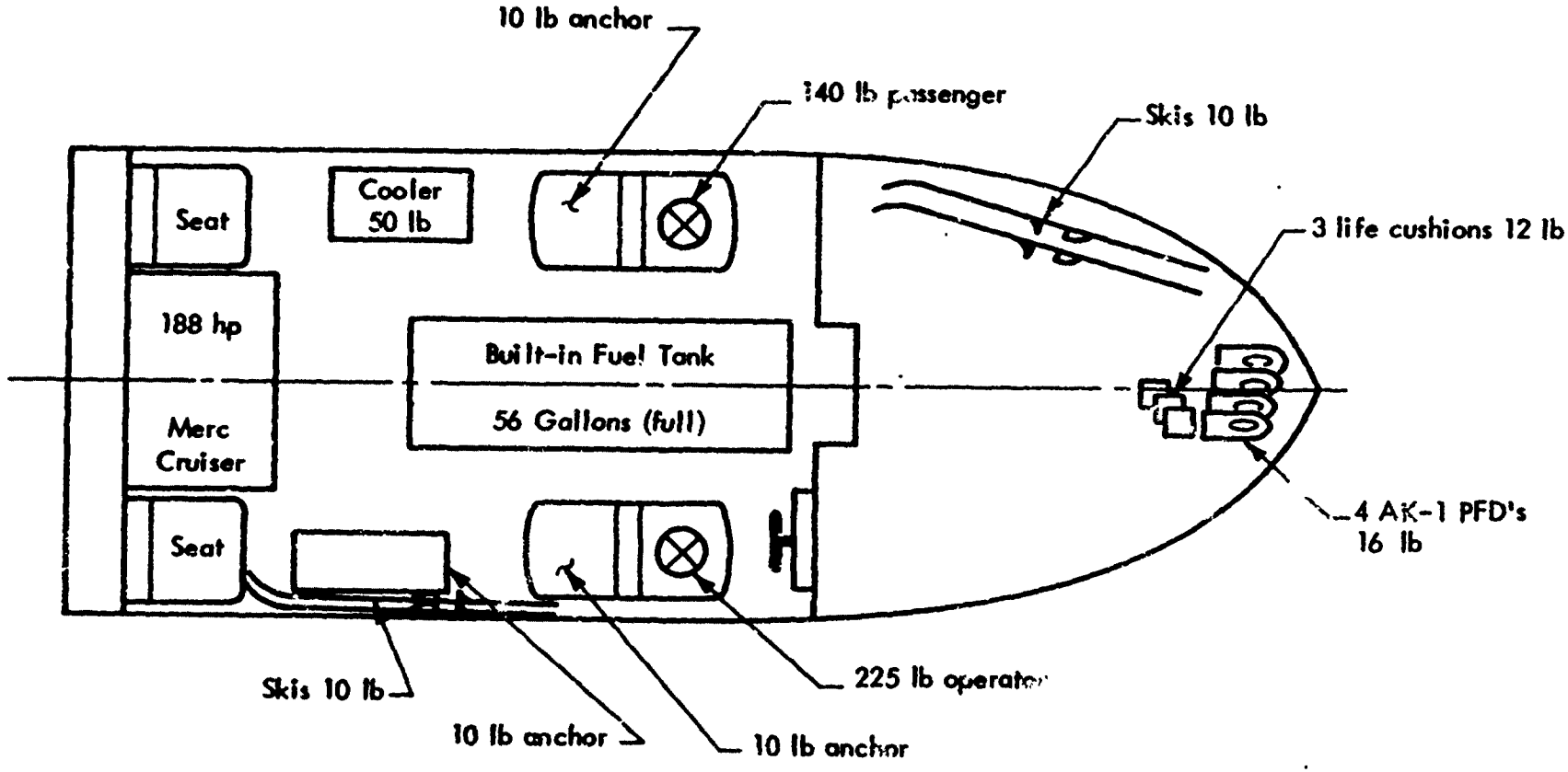


Figure 6. Locations of Occupants and Gear

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

In the interview, the operator said he thought the incident took place in Manistee. It actually happened in Ludington. The Ludington USCG personnel said that at the time of the accident the operator said he thought he was in Pentwater. Yet, during the interview, he said he knew he was north of Pentwater because he had seen two lighthouses that are near Ludington and passed them (and Ludington is north of Pentwater). It turns out that there are two lighthouses and Ludington is between them. It could be that one of the other ports south of Ludington had a light that was interpreted as a lighthouse. Thus, when the operator passed two lighthouses and headed in, he was heading for Ludington. It is curious that he was so confused and unfamiliar with the area when he claimed to have been a boater in the area for a long time.

The physical evidence at Ludington suggests that the operator may have made a hard turn to starboard just before he hit the wall because of the orientation of the scrape marks on the sea wall. The top of the sea wall is four feet above the waterline. The operator said he deliberately did nothing just before impact because he thought the boat would roll over if he turned. The condition of the boat also suggests that the boat hit the wall and leaned to the starboard because of the scrape marks just below the operator's station on the starboard side. From inspecting the wall and the boat, it appears that the boat may have been travelling faster than 20 mph when it hit the wall. The watch for the Ludington USCG station had heard this boat's loud engine noise over the sea noise and local traffic at a distance of approximately 2500 feet. He then tracked the boat's lights into the sea wall and alerted his comrades at the station who launched immediately to initiate rescue operations.

The operator never saw the inner and outer red lights that were closer to him than the green light that he did see. At some point in his approach to Ludington, these red lights had to have been in his visual field, although by the time of the accident, they may have been in his peripheral field. The fact that other boaters had complained about the two red lights suggests that they are not bright enough to be seen under some circumstances. The USCG personnel stated that other boaters who used Ludington Harbor had complained about the lack of visibility of the red lights. The operator's boat had its 360° white light mounted on the windshield about three feet from the operator. The windshield is narrow and the bow rails are in the line of sight and would reflect glare from the 360° white light (see Figures 4 and 5).

The operator stated that he had, at times, put his shoe over that light to reduce these problems, but had not done so on the night in question (and the USCG watch had seen his white light). Also, the operator had been awake for over 18 hours and probably was fatigued. It is possible that the bow of his boat was raised enough to restrict his forward vision. Thus, there are many factors that could have contributed to his not being able to see the sea wall or the red lights. In addition, the red light on the sea wall would be in his peripheral field right before he hit the wall. The periphery is more sensitive to red than to any other color and many people can identify red at an angle of 45° from their line of sight. It is possible that the brightness of the white light from the lighthouse prevented the operator from seeing the red light.

The operator also stated that he never heard any sirens or foghorns because of the loud noise generated by his engine, but he did hear the waves on the shoreline at what he estimated to be 250 feet. The operator was referring to the instant just before impact and his point of impact was actually 1400 feet from shore. The white lighthouse was 1600 feet from the point of impact, and was the location of the horn.

The investigating team saw the south breakwater at Manistee, as well as the one at Ludington, and they are very similar as viewed from the south. The USCG personnel at Manistee said that almost all of the ports within 100 miles had similar sea walls. Yet the operator headed in between the white and green lights (see Figure 1) and did not realize that by doing so he would cross a sea wall. The operator said the sea wall was "just above" the waterline (it was four feet) and the red light marking it was two feet above the water (it was over 20 feet up). He thinks he saw this red light as he was being rescued.

The operator's memory for thinking about turning, but deciding not to before impact, is striking in that: 1) the sea wall was a surprise, and 2) such memory immediately prior to such an accident is often lost.

6.0 PROBABLE CAUSES OF ACCIDENT

There are several factors contributing to this accident. These will be listed in the order of their probable importance in the accident with the most important cause listed first.

1) The operator's lack of knowledge of where he was and his inexperience with this particular harbor were major contributors to the collision. He did not follow the "red-right-return" rule, since he did not see any red lights. If he had seen only the interior red, and followed the rule, he would have hit the breakwater anyway. The fact that he still doesn't know where the accident happened is indicative of his confusion as to where he was. However, since his home harbor is very similar to this area, it is curious that he did not search out the red lights and use them as a navigational aid to avoid the breakwater. Education may have helped him.

2) Human factors also played a significant role in this collision. The operator was tired (he had been awake for 18 hours), fatigued (he had been on the water for nearly nine hours, five of them in the sun), and his boat's design contributed to reduced visibility. His 360° light is mounted on the windshield about three feet from his head and creates problems to the extent that the operator sometimes uses his shoe to cover the light. (After the accident, he bought another boat of the same model.) The bow rails are prominent in his field of view and reflect glare from the 360° light. The windshield is narrow, thus the trim is in his field of view. Finally, the bow of the operator's boat is large and glossy so that it would restrict his visibility (see Appendix). All of these points contributed to his inability to see the red lights or the sea wall. It is interesting that the operator heard the waves on the shoreline, but not the water against the sea wall. Could reduced engine noise have allowed him to "hear" the sea wall? Better lighting design and boat design could have reduced these problems.

3) The operator was probably going too fast under the conditions described. The statements by the USCG watch and the physical evidence suggest the boat may have been travelling faster than the 20 mph stated by the operator. If so, with fatigue, reduced visibility, and lack of experience in the area, the operator might have seen the wall in time to avoid it if he had slowed down.

4) The lighting in the harbor may have contributed to this accident. If several people have complained about the red lights, as was stated, then perhaps something should be done about them. They may be too high or too dim to be seen. At least, they should be made to operate at different frequencies so if a boater spots one he knows which one he has seen.

Also, the sea walls are very long (over 2600 feet) and the only lighting is at the end. Perhaps lights, reflectors, or "glow-in-the-dark" paint could be used to make the breakwater visible at night. This was not the first time that a boater had failed to see this sea wall and run into it. Thus, the harbor lighting could be improved.

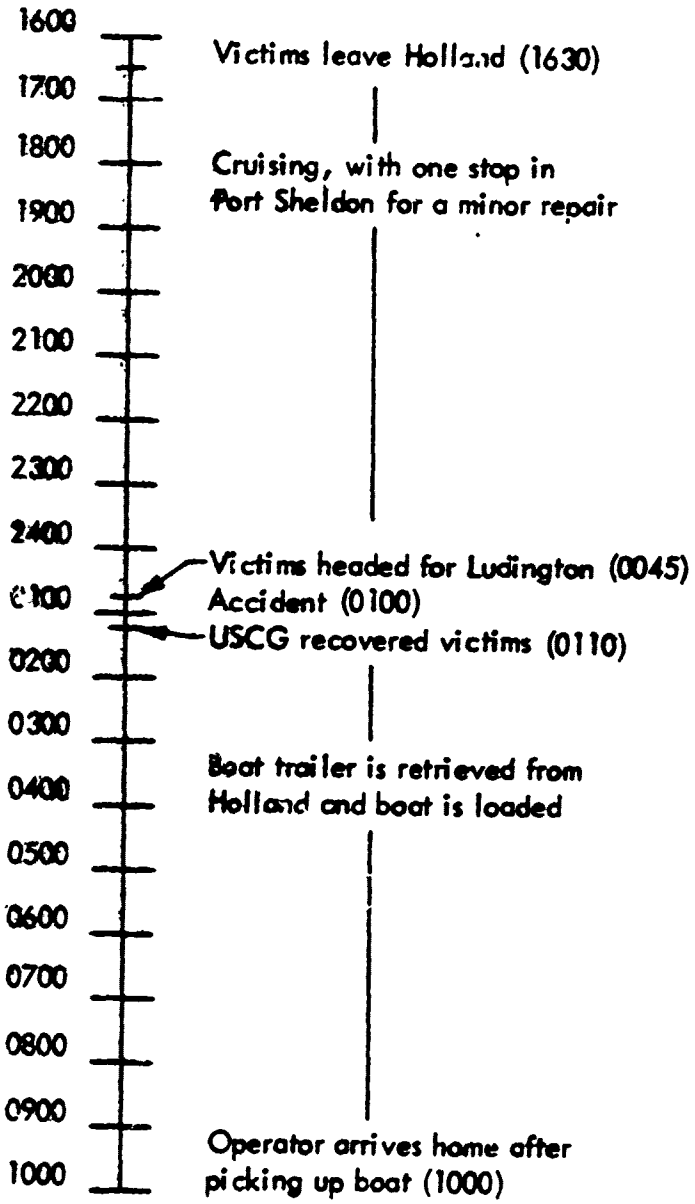
7.0 DYNAMICS/ANALYSIS OF THE ACCIDENT

At approximately 0045 on June 22, 1975, the operator of a sport cruiser turned his boat toward a port on the West Coast of Southern Michigan. The operator had been exposed to sun, glare, and heat for five hours, and he had been exposed to darkness and the poor lighting system on his own boat for over three hours. He had been operating his boat (experiencing vibration and noise) for over eight hours. The fatigued operator spotted a white light and a green light and headed between them to reach the port. He saw no other lights. The boat was traveling 20 mph or better. When the boat was approximately 1400 feet from shore (at 0100) it ran into a sea wall. The operator apparently turned the boat to starboard just before impact. He saw the wall, but did not have time to contemplate his actions. Upon impact the boat leaned to the starboard (causing the scraped gelcoat under the operator's position) and climbed on top of the sea wall. The momentum of the boat carried it just over the top of the wall and it fell to the other side.

At impact, the female passenger was thrown against the cabin wall in front of her seat, causing a shoulder bruise. The operator held onto the steering wheel, which bent under his weight and the force of impact. He also incurred a cut on his left arm, although the cutting edge is unknown. The portable grill that was on board was also thrown against the cabin wall and dented.

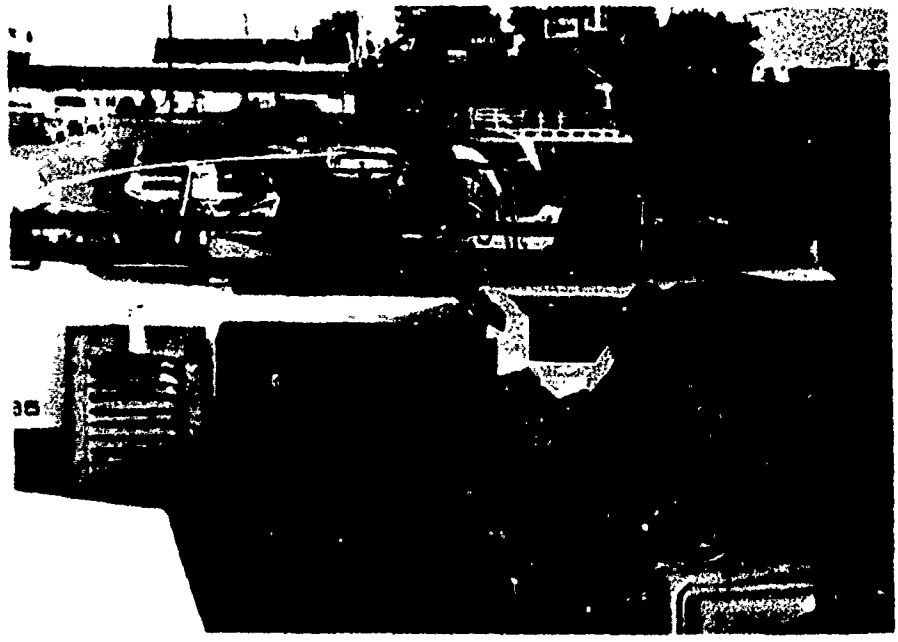
The lights on the sport cruiser went out at impact and the engine was locked in neutral after the boat fell over the sea wall.

TABLE 1. TIME LINE OF EVENTS IN THE ACCIDENT



APPENDIX A

INTERIOR VIEW OF BOAT AND BOAT SPECIFICATIONS



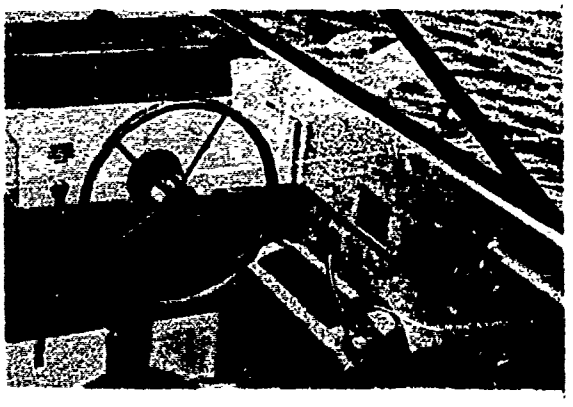
The Fun Seeker—SS235

Own your own passport to good times with this elegant pleasure craft. Round up the gang for a day of thrilling water skiing, a refreshing swim and some good food. What a way to entertain—fun loving hours your guests will find hard to forget!

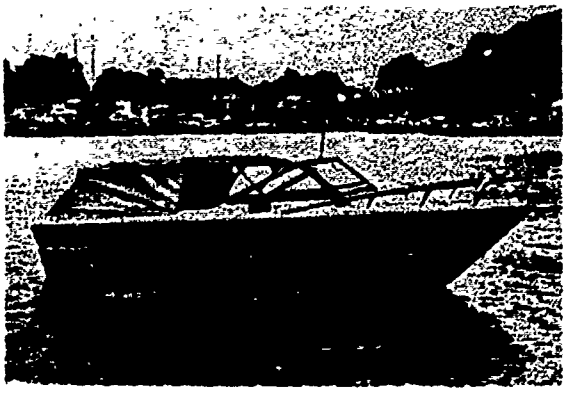
Or set yourself free from it all and putter around and explore the water world at your own pace. A fisherman you say? This boat will take you where the big ones are, and in complete comfort, convenience and safety.

STANDARD EQUIPMENT includes Slickcraft custom construction. **For engine, controls and fuel:** a 72 amp. hr. battery (per engine), an ammeter, speedometer, tachometer, fuel, oil pressure, and water temperature gauges. Each has fused 12V electrical circuits with back lighted switch panel, rack and pinion steering and an aluminum fuel tank. There is also a single lever shift and throttle, 3 blade propeller and power trim in Mercruisers and OMC (to 165). **For convenience and comfort:** a swim ladder, convertible top, stainless steel wheel, bow and stern mooring cleats, folding teak access hatch, translucent sliding deck hatch. Stainless steel bow and transom eyes, all weather carpet, locking glove box, and jump seats with ice chests. Also vinyl covered keepers, aluminum rub rail with replaceable vinyl insert, insulated fiberglass motor box, bow rail, internally wired and vented windshield, and laydown seats. There are 3" foam V-berth cushions, taffrail, fiberglass floor, head with holding tank and cabin lights. **For safety:** U.S. Coast Guard approved ventilation, non-skid decks and floors, fire extinguisher, electric bilge pump and blower, and closed cell foam. There is a horn, a 3½" compass, anti-glare instrument panel, navigation lights. **Additional features:** storage under seats, side panels, forward, and seat pockets. Solid teak trim and louvered teak doors. The boat is BIA certified with a 3 year hull warranty.

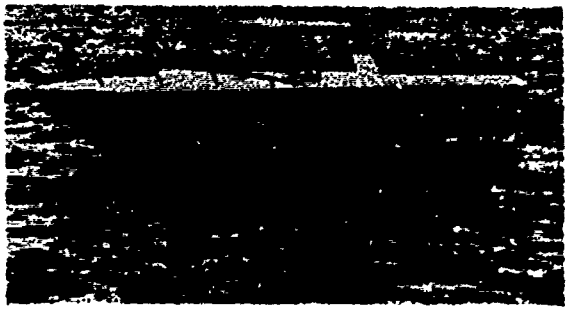
SS235 LINE SPECIFICATIONS		METRIC MEASURES
Center Line	22'10"	7.0 meters
Gunwale Length	23'8"	7.2 meters
Beam	96"	243.8 centimeters
Forward Depth	52"	132.0 centimeters
Cabin Head Room	51"	130.0 centimeters
Weight w/V-8 (approx.)	3160 lbs.	1433.0 kilograms
Deep V-Hull Configuration		
Cockpit Length	10'11"	333.0 centimeters
Fuel Capacity (U.S. gallons)	56	212.0 liters



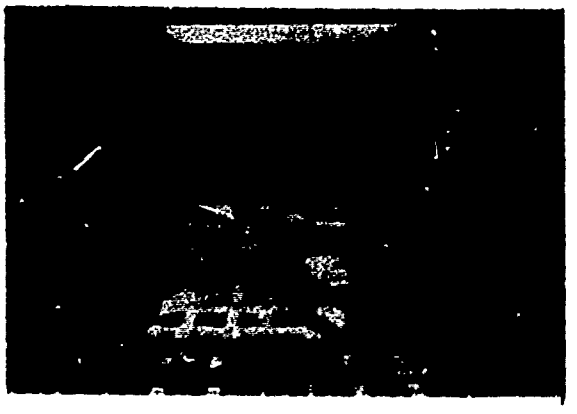
1975 handsome console with two cup holders



SS235 with full canvas and camper top



Optional hardtop



V-berth storage and bunk area

112-b
A-2

112-b

ACCIDENT INVESTIGATION REPORT

Date of Investigation: August 1, 1975

Date of Collision: July 23, 1975

Investigation: Collision No. 75-07

SUMMARY – WYLE ACCIDENT NO. 75-391

Just before dawn on the morning of July 23, 1975, a 97' ketch operating under motor only went aground on a sand bar near a small inlet on the South Carolina coast. The seas were three to six feet that night and the current in the immediate area approached 5 knots. After repeated attempts at powering off of the bar failed, the owner radioed for help. A shrimp boat picked up his distress call and informed the Coast Guard of the plight of the boat.

The Coast Guard launched two boats and sent a helicopter to the scene. All seven persons aboard the boat were lifted to safety by the helicopter. The boat broke up and was completely destroyed. No one was injured.

1.0 OCCUPANT DATA

Operator/ Passenger	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD's Worn
Owner	34	150	Good	100-500 hr	No	No
Wife	26	140	Good	100 hr	No	No
Son	13	120	Good	Passenger only	No	No
Daughter	4	40	Can't swim	None	No	No
Son	3	40	Can't swim	None	No	No
Owner's father	53	180	Good	Small boats	No	No
Owner's mother	49	130	Fair	Passenger only	No	No

The owner of this boat works as a construction engineer. He is a pilot, and served as an Army Officer during the Vietnamese conflict. Until recently, he worked in the construction industry in Florida. He and his wife purchased the Bugeye ketch and proceeded to spend the past year completely rebuilding the interior, while they used the boat as their home. The family had just moved to South Carolina and were planning to sell the boat and move ashore.

He had been sailing for fifteen years; however, most of his experience was in daysailers with some experience with a Morgan 41. He had no formal boating instruction and felt that he really didn't need it. He was convinced that his pilot training in navigation and military training in discipline and procedures equipped him with the knowledge and background to handle any emergency that might arise on the water. In fact, he said that if he could go through the experience again, he wouldn't do anything different.

The wife had little experience on boats until they bought their floating home. He taught her to sail and had confidence in her ability to handle almost any situation.

His parents are from an inland area and are only familiar with inland lake boating.

2.0 ENVIRONMENT

The weather for the three days that the boat trip plus accident cover was identical. High temperatures were around 89°. The winds were out of the south at 6 to 12 miles per hour. It was partly cloudy and the visibility was 7 to 10 miles. At the time of the accident, the winds were 5 mph. There was some precipitation recorded on shore on the night prior to the accident; however, the boat owner didn't mention rain so it may not have rained off shore.

In essence, it was beautiful boating weather, complete with a full moon.

3.0 NARRATIVE OF ACCIDENT

The following account of the accident is from interviews with the boat owner and the Coast Guard officer that led the rescue operations.

3.1 Pre-Accident

The owner and his family were in the process of moving from Florida to South Carolina. He had sailed the boat up from Florida and had arrived two weeks prior to the accident. His family didn't sail up with him, but met him in South Carolina and were living on board at a marina until the accident occurred. He reported that he had had problems during the trip north. The diesel engine had a major breakdown somewhere off the coast of Florida; therefore, the rest of the trip was made under sail alone. The jib was blown out during one of several severe storms that plagued the vessel on the way north, so an approach to the inlet was planned under mainsail alone.

As he approached the inlet, he noted that he could easily sail with the wind right into the harbor. But even though the inlet was well marked and large enough for aircraft carriers to pass through, the owner found himself to leeward of the entrance jetties and unable to tack to windward off the lee shore. He anchored, radioed for help and the Coast Guard towed him to port.

The next two weeks were spent at dock, while the inboard diesel was repaired. Full moon was approaching and the family planned an off shore, overnight fishing trip for the 21st and

22nd of July. They left early in the morning, for the off shore fishing grounds with his father and mother as guests. They sailed all day, all night, and on into the following day. Although the weather was good for sailing, most of his crew were plagued with seasickness.

The return trip was downwind so they decided to motorsail. It would get them home faster. However, engine problems developed, causing them to spend considerable more time returning to port than expected. The owner diagnosed the problem as fuel starvation and proceeded to clean filters while the rest of the crew sailed on. He found the problem, a clogged secondary filter, removed the debris, started the engine, and continued to motorsail.

In all, the engine problem cost them about six hours. Therefore, they would have to make their approach to the inlet after dark. Upon approaching the coast, they found that a ground haze had set in. A lighted buoy was spotted and was identified as the offshore buoy for the main channel into the harbor. The six lighted buoys marking the edges of the channel couldn't be spotted. The owner claimed that the ground haze prevented them from being seen. He also mentioned that the glare from the moon onto the ground haze bothered him to the extent that he felt that he could have seen the buoys if there had been no moon. He felt it was like the reflected glare from one's headlights in a fog. However, he said that he could see the lights of the city quite plainly. He proceeded to zig-zag towards the city in an attempt to find the buoys marking the edge of the channel. He couldn't find them. At approximately 0200 he decided that he should wait for daybreak. He was very tired and didn't want to run the boat aground. He gave the helm to his father and instructed him to head southeast, away from shore. The throttle was set so that the engine was running at a speed just above idle. The owner went below and slept.

According to the Coast Guard Officer that handled the rescue operations, the owner located the wrong offshore buoy. There is a buoy several miles south of the channel main entrance buoy that appears identical to that buoy with one exception. The flash rate of the light is 2-1/2 seconds as opposed to a 6 second flash rate on the channel buoy. This would explain why the other channel buoys weren't located.

At 0300 the owner was awakened by his wife who reported that they had spotted something but couldn't identify it. He arose, identified the object as a freighter and cautioned his father about the dangerous sandbars close to shore. He went back to sleep. The next thing he remembered was hearing and feeling a couple of thumps and hearing yelling on deck.

3.2 Accident

When he got on deck, he saw a beach ahead. He didn't know where he was, but he knew that he had to back the boat off of the bar. For approximately one half an hour he attempted to back the boat off. It wouldn't budge. Finally the rudder broke and was pushed up through the boomkin.

Although the seas had been about three feet, the breakers on the bar seemed more severe. The boat was beginning to break up. Water flowed into the cabin area and the batteries were covered, rendering the radiotelephones useless. He had a hand held C.B. transceiver on board and used it to transmit his mayday. A shrimp boat in the area heard his plea, called the Coast Guard, and came to stand by.

All hands donned life preservers. The children were placed on the cabin top because it seemed to be the highest and driest place. They tried to lower the dinghy, but it was smashed against the lee side of the boat before they could enter it.

They then inflated the rubber raft. A line was attached to the grommet in a special reinforced flap on the bow of the raft. The raft was lowered into the water. The second wave broke the flap and the raft floated away. The owner dove into the water to attempt to retrieve the raft. He caught it but was immediately slammed up under the bow sprit. His PFD tangled in the netting, and he was hung by the PFD when the wave passed by. He ripped off the PFD, fell into the water and was washed towards shore in the current.

His father saw his plight, grabbed a fishing rod, tied a cushion to the line and cast it out to him. He grabbed it. The line broke. A life ring was cast to him. The line broke again. A shrimp boat picked him up.

A second shrimp boat tried to get into the area to pick up the rest of the people on board, but couldn't get close enough.

Meanwhile, the Coast Guard didn't have a fix on their position; and, therefore, couldn't launch any rescue boats. They called the police department of the shore community in the area where they suspected the boat might be and asked them to check the coastline for a stricken vessel. They did. Lights were flashed from the police to the boat. The occupants of the boat fired a flair in return. The police notified the Coast Guard of the position of the stricken craft. Two boats and a helicopter were sent to the scene.

The helicopter lowered a basket to the boat. The wife and two small children entered the basket and were deposited on a beach. The owner's mother and third child were in the second basket load. By this time, the deck had broken away from the hull and had settled several feet lower into the water. The owner's father was left aboard and had climbed up to the boom to stay above water. He was picked up from the boom. The owner was picked up from the deck of the shrimper and all were taken to the Coast Guard Station. It was now about 0800.

3.3 Post Accident

Rather than attempt to salvage the boat himself, the owner decided to sign the boat over to a salvage company. The boat was a total loss. The salvage company did get the masts, a boom, the engine, generators, etc., and were still combing the area at the time of the investigation. None of the personal articles of the owner's family had been found to date.

4.0 FACTS FROM THE BOAT INVESTIGATION

The boat broke up in the surf; therefore, there was no boat to inspect. We do know that it was a 1947 model, 70 feet on deck and 96-1/2 feet overall from the end of the bow sprit to the boomkin. It was round bilged as opposed to the more normal hard chined Bugeyes and, unlike normal Bugeye's, it had a keel. It was ruggedly constructed with oak frames on 14" centers covered with 2-1/2" planking.

It was powered by a 100 horsepower diesel inboard and had 56 submarine batteries that provided electricity for refrigerators, lights, etc. for quite a while at sea. The boat was also equipped

with two generators for AC power at sea. The cabin was completely equipped as a house or home for a family of five.

Figure 1 approximates the plan and profile of the vessel.

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

There is a good probability that the buoy that the owner located and identified as the offshore channel buoy was actually a buoy located about 2 miles south and marked one corner of a rectangular disposal area. According to the local Coast Guard representative, the two buoys appear identical. The only difference between them is the flash rate of their lights.

The owner had been sailing for 42 consecutive hours with only a couple of hours sleep the night before. He was obviously fatigued. His family had been seasick throughout the trip and probably were quite anxious to get into the marina. He had had problems with the engine that had just been rebuilt the week before that took him most of the day to diagnose and repair. Therefore, he was fatigued from lack of sleep, noise, vibration, wind, sun, glare, etc. as well as stressed by family pressure to get home and stressed by mechanical failures on the recently rebuilt engine.

He had no formal boating education. He had owned boats in the past but had limited offshore experience. He apparently had a chart of the area on board, but it is questionable whether he studied it that night. He said that his pilot training taught him all he needed to know about charts and navigating, yet he didn't know about the high, bright, and very visible range lights at the harbor entrance. If he would have found the right offshore buoy, the range lights would have guided him into the inner harbor. There was no need to look for the channel marker buoys. He should have known that he located the wrong offshore buoy when the range lights didn't appear at the proper compass heading.

He obviously didn't use the appropriate and proper technique for entering this particular harbor at night. One does not "zig-zag" to locate a channel when one has already found the end of it.

One brings the boat to the proper compass heading, locates the range lights, and moves cautiously towards the inner harbor using the rest of the channel markers to locate one's position along the course.

Was it fatigue or simply lack of knowledge of offshore boating tactics that caused him to mistake one buoy for another, then apply the wrong technique for entering the harbor? We probably will never know. However, both seem to be education oriented. Boating safety courses stressing proper piloting procedures could have helped him to correctly identify the buoy even in a fatigued condition and could have helped him to determine the proper procedure for entering the harbor. He never took a boating safety course and claimed that he would do nothing different if he were able to relive the incident.

He did do the right thing, however, by admitting to himself that he was confused and disoriented and figuring that the safest thing to do was to head out to sea and wait for daybreak to find the inlet.

He told his father to motor on a southeast heading which was generally the reciprocal of the course into the harbor entrance and was into the wind and waves. He also set the throttle at a very low rpm because he didn't want the boat to get very far off shore. It appears that if his father actually maintained that heading, he was pushed backwards by the wind, waves, and current.

The tide tables for the area showed low to be at 0144 and high to be at 0749. They grounded at a small inlet that feeds a large marsh area. The current is quite swift through that area during the time that his father had the helm. Fatigue, other stressors, or lack of education could all have played a role in the fact that he handed over the helm to an inexperienced person, and didn't take the time to check his movement over the ground by taking cross bearings on objects on shore. Instead, he went straight to bed.

After the grounding took place, he spent a half an hour trying to power off and didn't call for help until it was almost too late. In fact, if the helicopter hadn't been able to pick the

people off the boat, it would have sunk completely before Const Guard boats could have gotten to them. Apparently, the owner was so caught up in trying to save his boat that he didn't realize how fast it was actually breaking up and didn't project ahead to determine how long it would be until all of the occupants would have to take to the water.

Both the owner and his father do not drink alcoholic beverages.

6.0 PROBABLE CAUSE OF THE ACCIDENT

A series of operator errors led to the grounding and total destruction of this boat. First, the operator misjudged his position along the coast and when a buoy was spotted, assumed it to be the one he was looking for. Actually, it was identical in appearance except for the flash rate.

Next, he didn't use proper procedures, or common sense for that matter, in his attempt to locate the channel leading to the inlet and harbor.

Third, he didn't check his speed over the ground when he idled back and handed the helm over to his father. It is quite probable that his boat was actually making sternway over the ground. His father, an inexperienced booter and quite fatigued himself, didn't take bearings and didn't realize he was approaching land.

Therefore, the causes of the accident can be attributed to fatigue, which is defined as the cumulative effects of lack of sleep for some 42 hours, wind, glare, sun, vibration, and noise, plus a lack of education in offshore piloting techniques.

7.0 DYNAMICS/ANALYSIS OF COLLISION

If the boat would have had more power, it very well could have backed off through the swells and breakers as the boat was lifted off the bar with each swell.

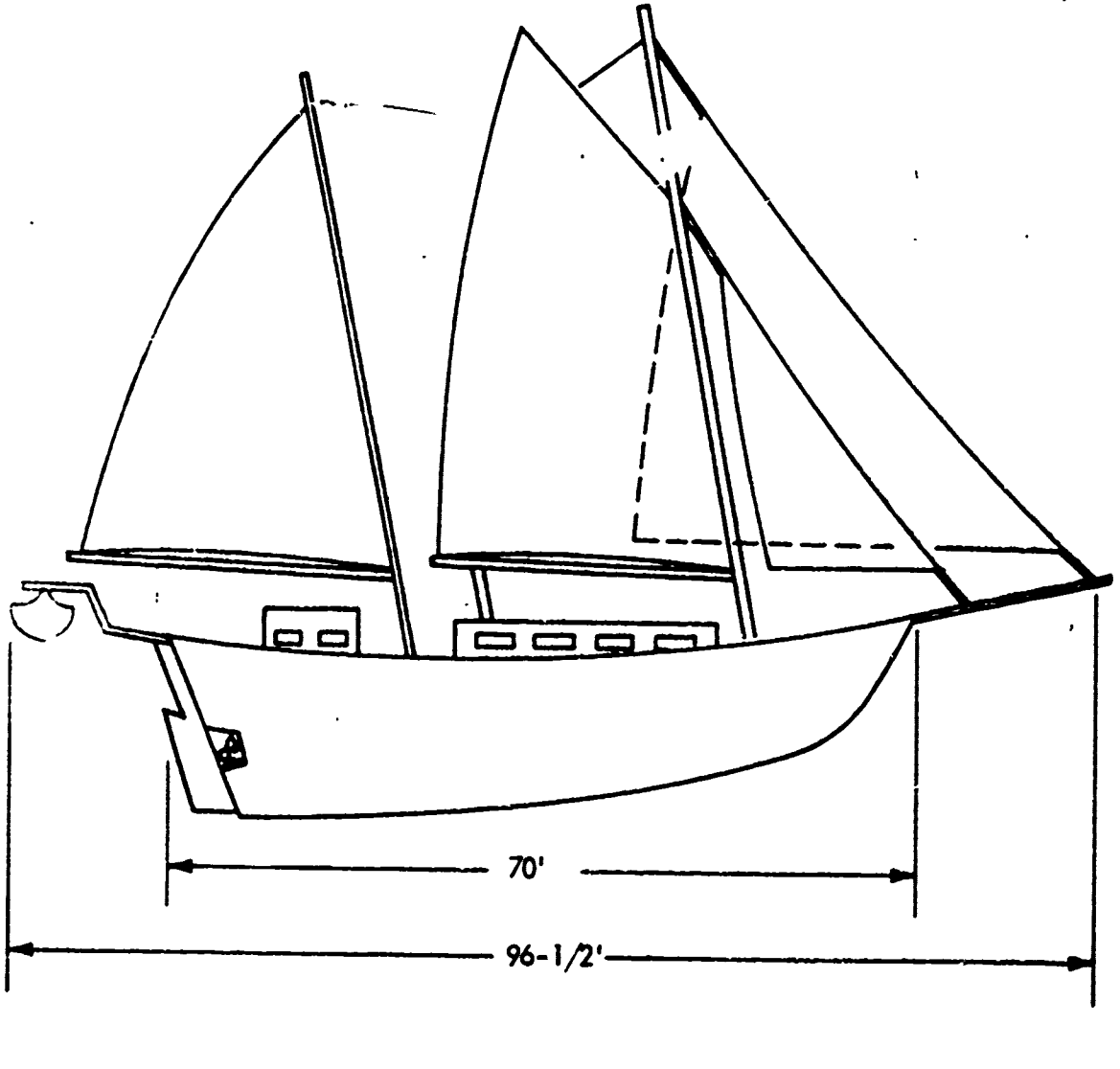
But, once aground the relatively low horsepower engine could not power the boat off the sand bar. The owner did not attempt to try to heel the boat by kedging off or by placing weights on the end of the booms and swinging them abeam. According to the chart of the area, that technique would probably have worked, but then hindsight is always 20/20.

The boat broke up completely within two hours. It is impossible to determine whether the rapid rate was due to the size of the surf or the condition of the structure of the 28 year old wood boat. Since the surf was estimated to be between three and four feet and the bottom was sandy, it is possible that a newer fiberglass boat could have withstood the battering and could have been pulled off with relatively minor damage.

Perhaps the owner would have been able to locate a main channel buoy that was obviously different from other buoys in the area. There is reason to believe that a change in some aids-to-navigation could result in a reduction in the number of accidents. Some breakwater collisions, as well as this grounding, may have been prevented if some aids were changed.

TABLE I. TIME LINE OF EVENTS IN THE ACCIDENT

21 July	0600	Left marina for offshore fishing grounds
	1200	Fished during day
22 July	2400	Family got very little sleep due to seasickness
	1200	
	1300	
	1400	
	1500	Decided to come in (motorsail)
	1600	
	1700	
	1800	Had engine problems
	1900	
	2000	
	2100	
	2200	
	2300	
23 July	2400	Saw offshore buoy
	0100	Couldn't find channel into harbor
		Decided to abort until dawn
	0200	Owner went below to sleep
	0300	Wife awoke owner - he went back to bed
		Boat grounded
	0400	Owner tried to back boat off
	0500	
		Owner radioed for help
	0600	Owner jumped overboard
		Coast Guard helicopter arrived
	0700	Helicopter rescued all people
	0800	All arrived at Coast Guard station



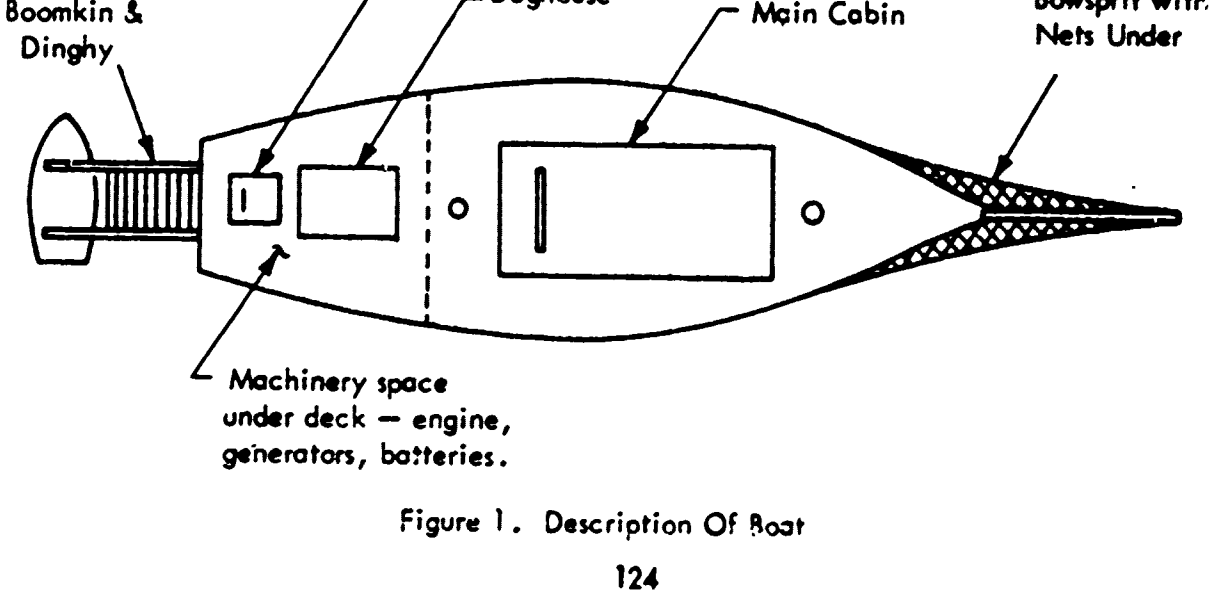


Figure 1. Description Of Boat

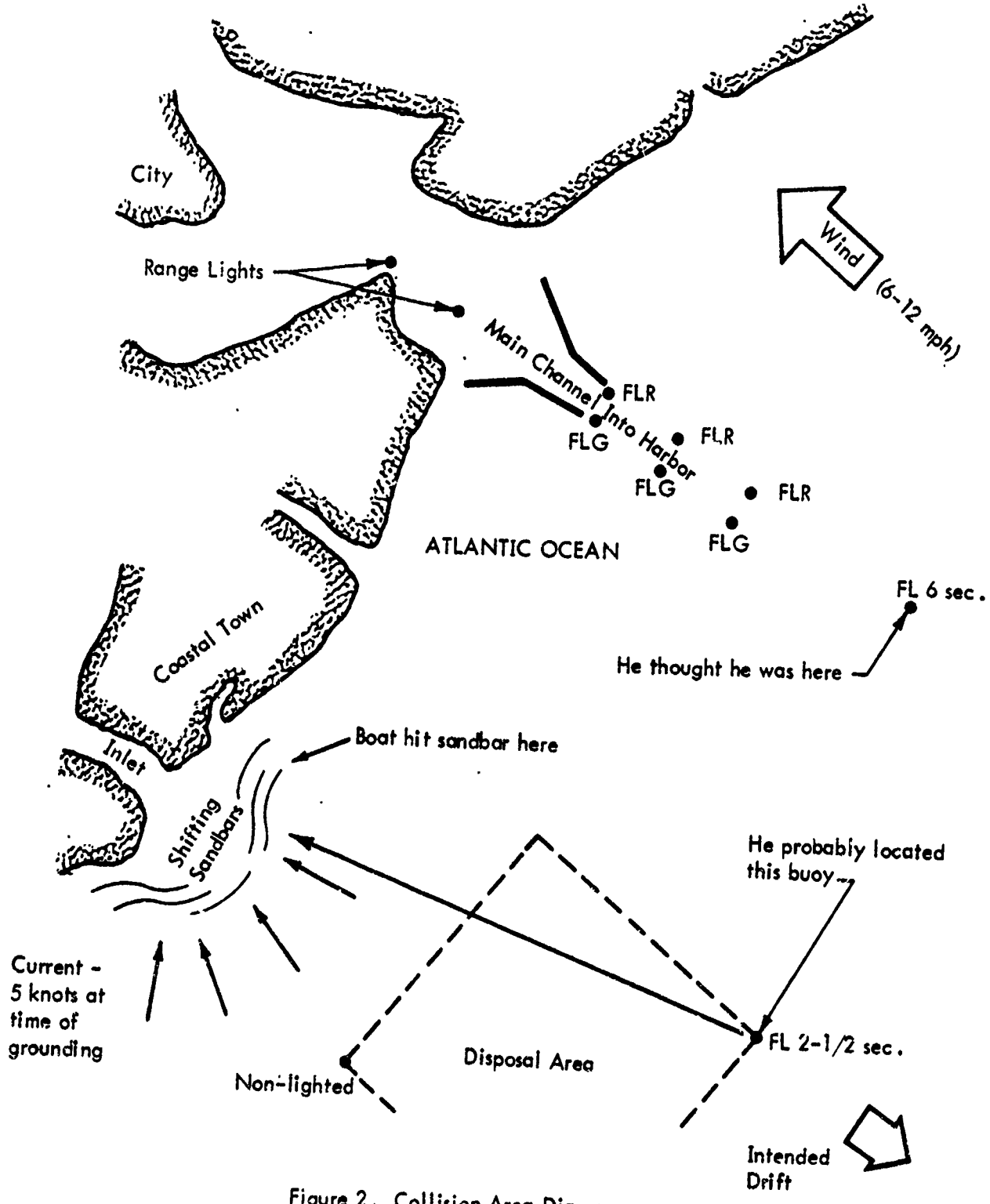


Figure 2. Collision Area Diagram

ACCIDENT INVESTIGATION REPORT

Date of Investigation: 1 August 1975

Date of Accident: 29 June 1975

Investigation: Collision No. 75-08

SUMMARY — WYLE ACCIDENT NO. 383

Two small boats were travelling in opposite directions on a narrow winding creek. The area was marshy with tall grass growing along the banks; therefore, the seated boat drivers couldn't see the water around the corners. Both boats were on a plane with a closing speed of about 40 mph. They met halfway into one of the sharpest corners on the creek. One boat struck the other, who was towing a skier, in the side of the bow and spun it around. The hitter continued straight and ran up into the marsh area on the outside of the turn.

No one was injured and relatively little damage was done considering the closing speed. There were no witnesses. The two operators had quite different opinions as to the actual track and location of one of the boats at the time of the collision. Both stories are presented and conclusions drawn.

It seems as if operator inattention, proceeding too fast for conditions, and possibly negligence and alcohol were the primary causes for this accident.

1.0 BOAT OCCUPANT DATA

Boat # 1 - Hitter

Occupant	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD Worn
Owner/Oper.	M	26	165	Excellent	500	No	No
Passenger	M	26	210	Good	100	No	No

The owner/operator was a young family man recently graduated from college and currently working as an optometrist. He had owned boats for about eight years and, in fact, owned this boat for six years. He thought of himself as being an avid fisherman; however, it appeared that he also enjoyed zipping around in the many creeks and tributaries in the area.

Little is known about the passenger. He was a friend of the owner and often went fishing with him. He was seated at the time of the accident and apparently was not directly involved; therefore, he could be considered only as a fixed weight within the boat.

Boat # 2 - Hittee

Occupant	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD Worn
Operator	M	16	125	Good	50-100 hr	No	No

The operator of this boat was the son of the owner of the boat. He and his brother often use the boat in the creeks around the area. They enjoy cruising around and towing each other on a surfboard.

The johnboat involved in the collision was the smaller of two boats that the family owns. The other is a 14' copy of a Boston Whaler type boat.

2.0 ENVIRONMENT

The collision occurred at about 1400 on a clear day. The air temperature was around 85 degrees, and the wind strength was between 5 and 10 mph, which barely rippled the surface of the narrow creeks. The water temperature was comfortably warm.

3.0 NARRATIVE OF ACCIDENT

The following narrative was formulated from interviews with the operators of both boats involved in the accident.

3.1 Pre-Accident

Boat # 1

On the morning of the collision, the owner of the boat arose at about 1000. His friend called and suggested that they go fishing. He agreed, got his equipment together, ate lunch, and left his apartment, with his boat in tow, headed for his friend's house and the launch ramp; a ten minute trip.

They launched the boat and drank a beer while waiting for the outboard engine to warm up. In order to get to their intended fishing spot, about two miles away, they could have proceeded west along the creek in which they put in and turned north where it met a small river. Instead, they elected to take a longer route along a very narrow winding creek. The passenger sat on two cushions in the center of the boat, just forward of the console. They got the boat up on plane, at a speed of about 20 to 25 mph and opened up another beer.

They proceeded along the narrow winding creek at this speed, always sticking to the right side of the creek while negotiating the sharp turns. The creek was bordered by a marsh area covered with a thick crop of marsh grass about 4 ft tall. Since the operator's head was below the tops of the marsh grass, all sharp corners were blind ones. He relied on other boaters heading in the opposite direction being on their right side of the creek. He wasn't particularly worried though because there is never much boating traffic on that creek.

Boat # 2

The two teenaged boys walked their boat/trailer combination down the street to their grandfather's house at about 1000. They launched the boat into the canal behind the house and motored out into the creek. They beached the boat, swam for a while, then proceeded to tow each other on a surfboard through the winding creek.

3.2 Accident

Boat # 1's Story

Boat number one was rounding the sharpest of the righthand turns along the creek. Marsh grass on the inside of the turn prevented him from spotting any boating traffic ahead. He was on the right side of the creek, quite close to the bank and moving at about 25 mph. He almost completed the "hairpin" turn when he spotted a johnboat coming at him on his side of the creek. He decided to turn right, hug the bank and go behind the johnboat. However, he changed his mind when he saw that the johnboat operator was towing a person on a surfboard. The driver of the johnboat was holding the engine control lever with his right hand, was turned to the right and was looking over his right shoulder, so there was no chance that he would see this boat and attempt to maneuver out of the way. Because he was afraid of running over the person on the surfboard, this boat's operator changed his mind and suddenly turned to the left in an attempt to cross in front of the johnboat. He never touched the throttle.

As can be seen from the collision area diagram, Figure 1, and the photo's, the left front corner of his boat contacted the left side of the johnboat about three feet aft of the bow. The johnboat spun around to the right, allowing this boat to pass in front of it without further contact. This boat's operator held onto the wheel with both hands, did not attempt to stop the boat or turn, and drove it up into the marsh on the outside of the curve. He then shut off the engine.

Boat # 2's Story

The operator of this boat said that he was driving on the right side of the creek and was just approaching the curve. He noticed another boat coming around the curve. It was hugging the inside of the turn, but the operator wasn't paying attention. He was looking to his left, at the shore area on the outisde of the turn. The other boat suddenly straightened out and crossed the creek, heading on a collision course with this boat. This boat's operator yelled. The passenger in the other boat saw this boat and tried to get the other boat's operator's attention. At the last moment, the other boat's operator saw this boat and he turned left. This operator turned right. The other boat hit this boat on the left side, spun this boat around, and continued on into the marsh. This boat's operator quickly shut off his engine, and surveyed his damage. He noted that no water had entered the boat during the accident, but that water was seeping into the boat through some cracks in the lower portion of the hullside. The "skier" entered the boat and they went over to the marsh to find out what happened to the other boat.

3.3 Post Accident

After determining that there was little or no damage to their boat, the operator and passenger of boat number one attempted to lift their boat out of the marsh, but it wouldn't budge. The two operators exchanged words about accident reporting, right-of-way, observers in boats pulling skiers, etc., then the johnboat operator helped pull boat number one out of the marsh. He tied his ski rope to boat number one and pulled with his boat while the occupants of boat number one pushed. The boat slid across the marsh and back into the water.

According to the operator of boat number one, the two boys decided not to report the accident and sped off down the creek immediately after pulling boat number one out of the marsh. Boat number one followed after having some difficulty starting their engine but couldn't find the boys or their battered boat. He said that he wanted to make sure that they got back safely since they had a big hole in their boat. The boys couldn't be found, so the occupants of boat number one went fishing as planned.

Actually, the boys' grandfather's house was close by. They had pulled into the canal behind his house and had lifted the boat out of the water and up onto the trailer. Their parents decided that they should report the accident to the authorities and did so.

When boat number one returned to the launch ramp, they were confronted by the Game Warden. All parties involved then proceeded to the Magistrates Office.

4.0 FACTS FROM THE BOAT INSPECTIONS

Boat # 1

The owner had bought this boat new six years ago and had used it quite frequently for fishing and just riding around in the local area. It was an open fishing boat with a semi-v hull 14' 2" long and 5' 2" wide. It weighed 375 lbs and was powered by a 50 hp outboard motor. Essentially, the boat was a single piece fiberglass casting with a plywood floor glassed in place. Construction details and hardware suggest that the boat was built to appeal to those primarily interested in low price. Fiberglass patches in several locations in the vicinity of the bow indicated that the boat had been in collisions previously. The owner claimed that he hit a log. It was obvious from the inspection that the owner had used the boat hard and had done little or no maintenance to the boat other than patch holes in the hull.

Damage from the subject collision was slight. Impact occurred on the port forward corner of the square bow. A cast aluminum sheer cap made contact with the other boat. Impact forces were transmitted through pop rivits to the thin fiberglass shell. The fiberglass cracked for a length of about three inches at the corner. The owner said damage was so slight that he wouldn't bother fixing it.

Boat # 2

This boat was a 14' aluminum johnboat with a 45" beam at the gunwale, a 30" chine beam, and weighed approximately 75 lbs. It was powered by a 9 hp outboard motor. The owner of the johnboat wasn't sure how old it was. He had bought it used about five years ago, and thought it was probably a year old when he bought it. Before the collision, the boat was probably in average condition for its age.

Impact occurred about three feet aft of the bow on the port side. The hullside fractured and caved in. The boat probably twisted quite a bit since the metal around many of the rivets holding the seats and other supports in the area of the impact showed signs of stress. The owner had straightened the hullside and had begun to secure an aluminum patch over the cut in the hullside. The small cracks around some of the rivets were going to be fiberglassed. They fully intended to continue to use it in the creek.

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

The kids were out on the water having fun. School was almost out; it was exam week; they didn't have exams that day; so they took off in their boat to have fun. The traffic on the creek was quite sparse. A collision with another boat was the last thing in their mind.

They said that they had a cushion on board. The other operator said there was no PFD aboard of any sort. They didn't care. These were two kids out celebrating the beginning of summer and the end of school. They were inattentive. They may very well have been on the left side of the canal. What did they care?

The operator of boat # 1 had the day off. He was relaxed; going out with his friend to do what he liked to do best...fish and cruise around. He was out to have fun. In the 15 minutes since he had launched, he had downed 2 quick beers. He was up on plane, had just passed a no wake zone according to the two boys, and was zipping around a "hairpin" turn. A blind one at that. He knew the creek well and must have loved to speed through it, because he purposely chose to take it that day even though it increased the distance to the intended fishing grounds.

Considering a 40 mph closing speed and the fact that both boats were probably on the inside of the turn, he didn't have long to make his decision as to whether he should go behind or in front of the johnboat. The other boat was probably less than 150 feet away when he first saw it. Therefore, he would have had less than 3 seconds to maneuver out of its path. He hesitated and weighed the consequences of trying to go behind or in front of the other boat. It is interesting that he never thought to stop! He never touched the throttle and, in fact, became quite defensive when asked why he didn't slow it down or stop it.

When he finally elected to go in front of the johnboat, it was too late. He rammed the side of the boat. The johnboat swung around out of his way, and he continued frozen at the wheel into the marsh. He still never touched the controls.

The possibility exists that he froze at the wheel when he suddenly saw the other boat. His story about deciding to go in front of the other boat may have been just that ... a story. The fact that he became defensive when questioned in this area supports the possibility of the theory.

In any case, he didn't slow down. Neither did the johnboat. This investigator doesn't believe that the boy in the johnboat ever saw the other boat. One reason may have been the fact that the johnboat's bow was so far in the air. He was still under power at the time of impact. That boat/motor combination was never intended to pull a skier. There just isn't enough power. The fact that the gunwale on the larger boat hit about 4 inches above the static waterline of the johnboat supports the bow up theory. Also, considering the tremendous additional drag of the surfboard, the johnboat could have stopped in just a few feet if the operator would have seen the other boat. He didn't slow down until after the collision.

6.0 PROBABLE CAUSE OF THE ACCIDENT

The causes of this collision seem to be:

- Boat # 1 was going too fast for conditions. The operator couldn't see around the sharp turns, but was going about 25 mph, anyhow.
- The operator of boat # 2 was probably looking aft at his skier and may not have been able to see forward, anyhow, becuuse of the bow up attitude of his boat....inattention.
- Without the two beers, the operator of boat # 1 may have been going slower, or may have been cble to make an evasive maneuver with less reaction time, thus avoiding the collision.

7.0 DYNAMICS AND ANALYSIS OF THE ACCIDENT

The location of the damage on the two boats gives an indication of their planing attitudes at the instant of impact. Boat # 1 was running flat; it was up on plane and was well balanced with the driver and passenger both sitting on the longitudinal centerline with their combined C.G.'s just aft of amidship. Being flatbottomed with soft chines, it was probably skidding through the turn with just a slight amount of inward heel. The operator saw the johnboat, hesitated for a second then turned somewhat to the left. He probably didn't turn sharply to the left; in fact, he may have just straightened the engine out from its rather sharp right turn position. We feel that this is the case, since the operator froze at the wheel at impact and rode the boat straight into the marsh. If the wheel had been turned to the left, he would have gone in circles or at least turned somewhat to the left before entering the marsh.

The johnboat, on the other hand, was riding bow high. The operator was seated aft with no weight forward to balance the boat. He was pulling a 200 lb person on a surfboard with a 9 hp motor. The drag was such that the boat would not get up on plane. However, the thrust of the 9 hp outboard was sufficient to run the boat at the awkward "hump speed." The bow was up in the air, probably above eye level, and directional stability was quite poor. The teenage operator had his hands full trying to adjust the steering arm on the engine to keep the bow from falling off to one side. The additional turning moment due to uneven transom loading by the skier made the operator's job even more difficult. Under those conditions, an experienced person would have had quite a problem attempting to traverse a course that would be generally on the right side of a 75 foot wide canal.

The johnboat's bow was high, making the center of lateral resistance of the hull quite close to the transom. Therefore, when Boat # 1 hit the side of the johnboat, near the bow, the johnboat pivoted about its center of lateral resistance, and in effect, moved out of Boat # 1's path, thus avoiding far more serious damage.

TABLE I. TIME LINE OF EVENTS IN THE ACCIDENT

0800	No. 2 operator arose
0900	
1000	No. 1 operator arose - No. 2 operator launched boat
1100	No. 2 operator beached boat and swam
1200	No. 1 operator ate lunch
	No. 2 operator towed brother on board
1300	
	No. 1 operator launched boat and drank two beers
1400	Collision occurred
	No. 2 operator reported accident to authorities
1500	
	No. 1 operator arrived back at launch ramp
1600	

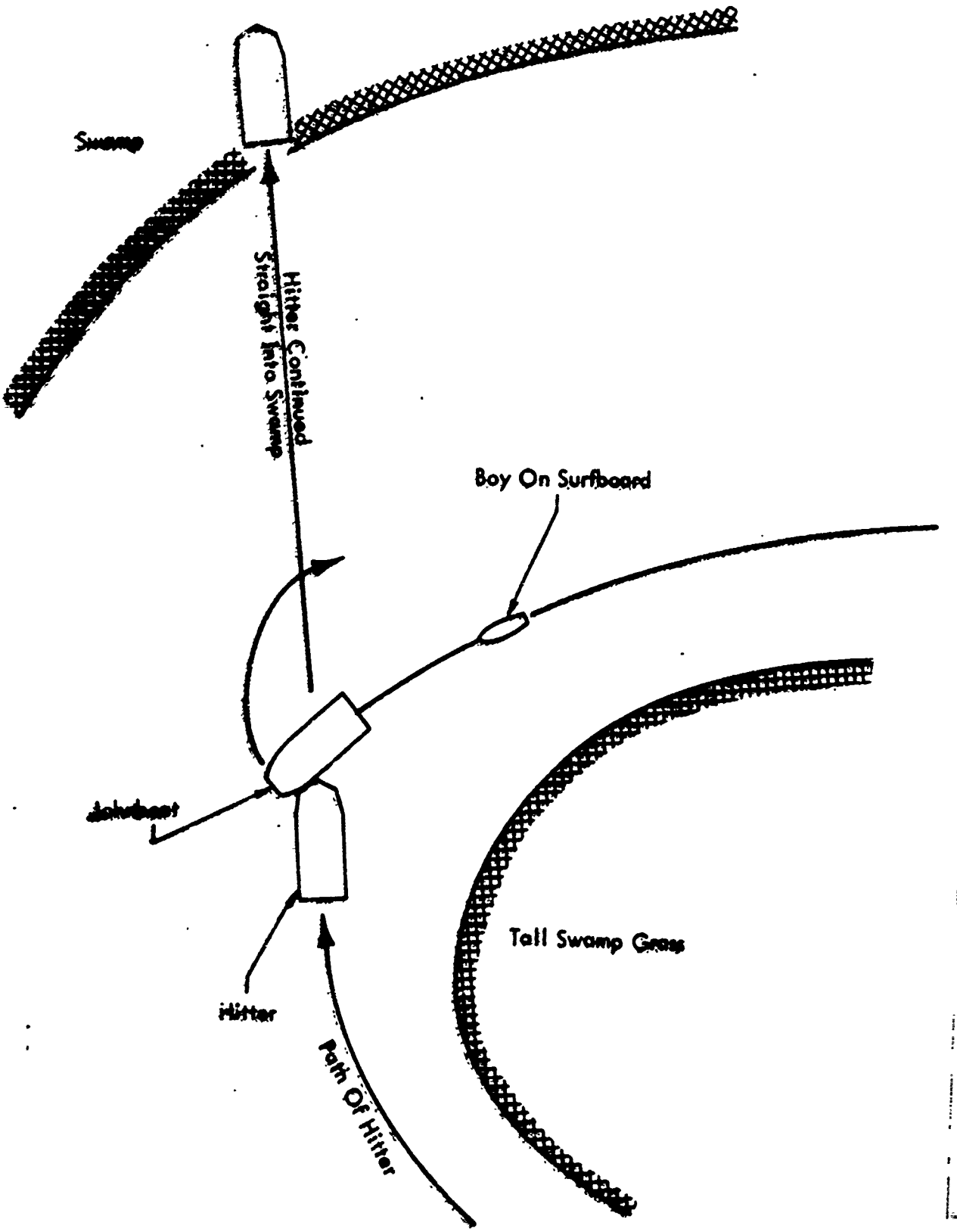


Figure 1. Accident Area Diagram

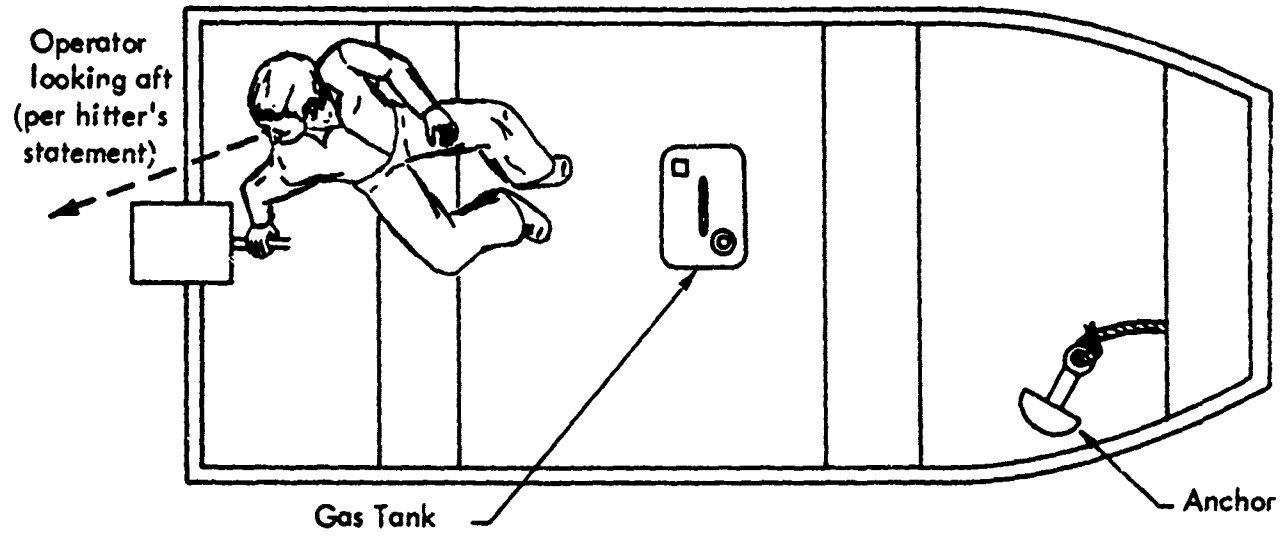


Figure 2. Plan Of Johnboat

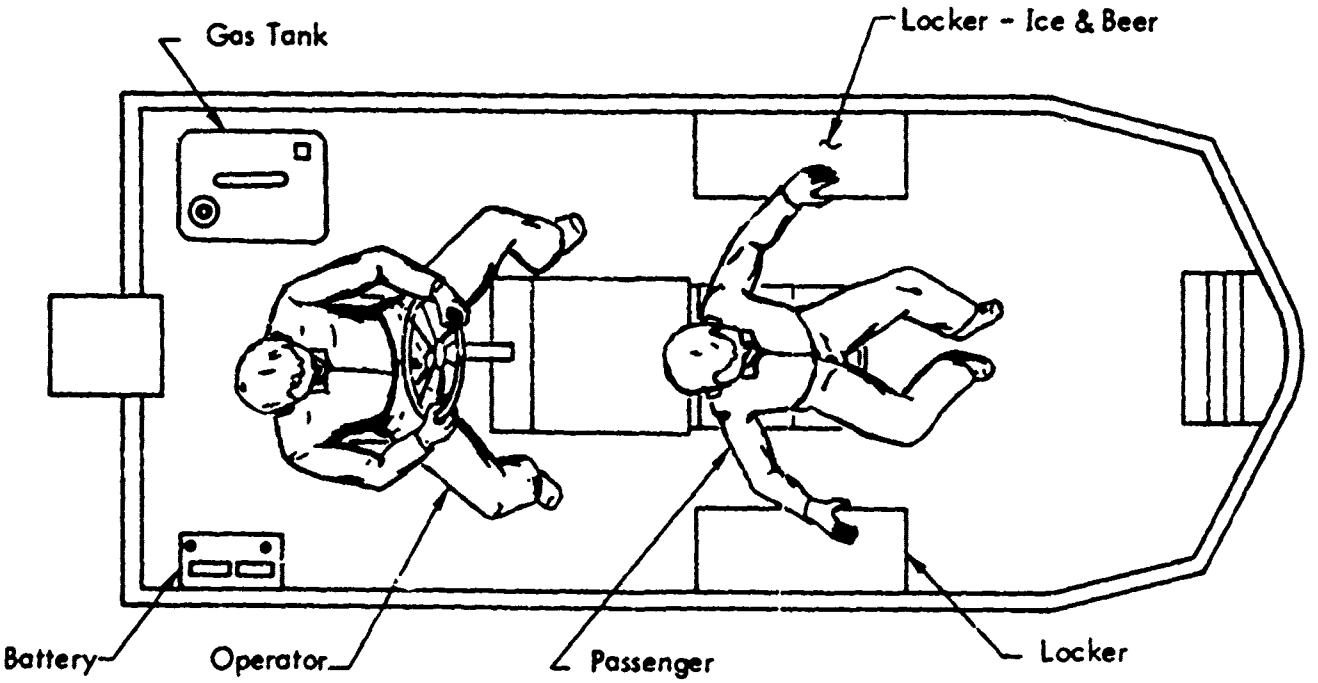


Figure 3. Plan Of Open Boat

Figure 4 Canal Close To Collision Site

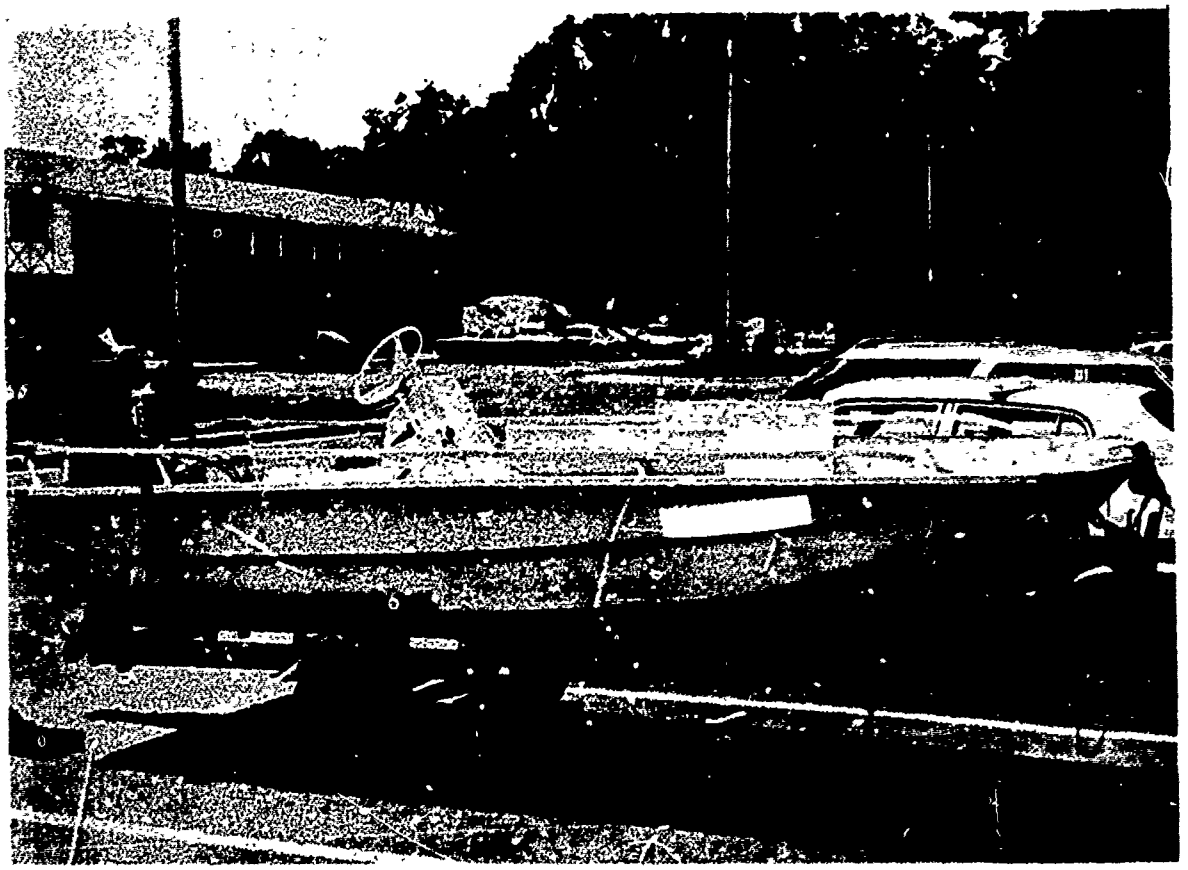


Figure 5 Profile Of Hitter

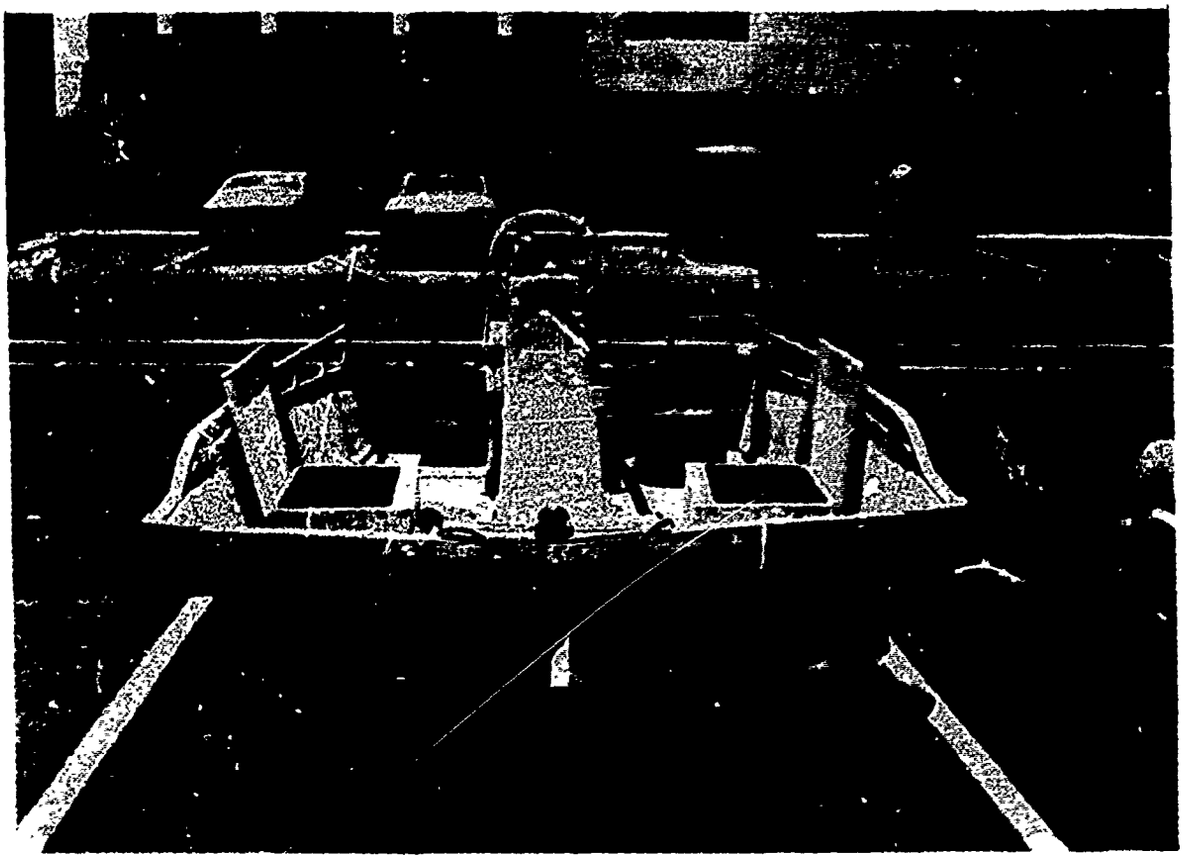


Figure 6 Bow Of Hitter

Figure 7 Johnboat - Note Patch Over Damaged Area

ACCIDENT INVESTIGATION REPORT

Date of Investigation: 30 July 1975

Date of Accident: 22 June 1975

Investigation: Collision No. 75-09

SUMMARY — WYLE ACCIDENT NO. 75-392

A family of four was boating on an inland lake in two johnboats. Neither boat was big enough to hold the four people, so a man and his daughter took one boat and his wife and second daughter took the second boat. They had launched just prior to lunchtime, motored to a picnic site, ate lunch and were motoring back to the launch ramp. The husband's boat was in the lead. A third boat with one person aboard and pulling a skier came towards the lead boat from behind an island. The operator of the ski boat was looking aft. The operator of the lead johnboat had his back towards the ski boat. The ski boat hit the johnboat and threw the operator out. The johnboat with the little girl aboard continued on a straight path for over 50 yards, then proceeded to turn in tight circles.

The operator swam to the boat, held onto and reached over the gunwale and shut off the engine. The boat capsized. The little girl was put into the second johnboat and was taken to shore. The overturned johnboat was towed to shore and righted. The operator dewatered the engine and got it running. He then straightened the side of the boat and drove it back to the launch ramp. His wife and two children followed. No one was injured, but the owner felt that the johnboat was totaled.

1.0 BOAT OCCUPANT DATA

HITTEE

Operator/ Passenger	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instructions	PFD's Worn
Operator	M	33	150	Good	< 500 Hrs	No	No
Passenger	F	4	40	No	None	No	Yes-Vest

The owner/operator of the johnboat that was hit worked as a mechanic and lived in a lower middle class subdivision. He enjoyed boating and had owned small lightweight boats for 10 or 12 years. He fished in the summer and hunted in the winter from his boats. His wife also enjoyed the boats and seemed to be quite content with the two boat arrangement when they would go on a family outing. (The second johnboat with his wife and daughter on board was not directly involved, so data about them is not included here.) Neither he nor his wife drink alcoholic beverages.

HITTER

Operator/ Passenger	Sex	Age	Weight	Swimming Ability	Boating Experience	Formal Boating Instruction	PFD's Worn
Operator	M	U	U	U	U	U	No

2.0 ENVIRONMENT

The weather on the day of the collision was perfect for boating. The temperature was in the low 90's. There was very little wind and it was bright and sunny. Water temperature was in the high 70's and water depth was 75 to 85 feet.

3.0 NARRATIVE OF THE ACCIDENT

The following narrative has been compiled from an interview with the hittee, his wife, and a telephone interview with the hittor. A personal interview was set up with the hittor at his residence, but when the investigator arrived on the scene he found that the hittor was out of town and couldn't be reached. The father of the hitter was interviewed briefly and the hittor's boat was inspected.

3.1 Pre-Accident

The family arose at their normal hour and went grocery shopping. They ate a brunch, packed a lunch, gassed up and took their two johnboats to a nearby lake for an afternoon picnic. They launched and loaded the boats. The boat that he drove was the smaller and less stable of the two. His four year old daughter went with him and sat on the floor of the boat just forward of the aft thwart and between his legs. The gas tank was on one side of her and the battery was on the other. An electric trolling motor was forward of her and a tackle box and anchor was in front of the center thwart. She was wearing a life vest and was sitting on a Coast Guard approved buoyant cushion. He was not wearing a PFD, but was sitting on a cushion also.

His wife took the second daughter in the other johnboat. It was shorter, but quite a bit wider so it had better transverse stability. She took the cooler, tool box and fishing rods in her boat.

They travelled to their favorite spot and picnicked, but were unhappy with the amount and type of boating traffic. He complained that there were too many skiers crowding the small tributaries of the lake. He noticed an unsafe condition and noted to his wife that someone was going to get hurt with that many boats going that fast in that little area. They lunched and swam off a beach for a while, then loaded the boats for the return trip in the general direction of the launch site. He said that they had considered the possibility of stopping for some fishing along the way.

They came out of the crowded tributary into the main part of the lake and turned left to go between an island and the shore. He was in the lead and she was following some 75 to 100 ft behind. They were travelling at about 15 mph.

3.2 Accident

A runabout with one person aboard pulling a skier rounded the island and ran into the aft starboard side of the lead johnboat. The wife of the johnboat owner saw the runabout rounding the island and observed that the operator was turned facing aft, watching the skier. She also noted that he was heading directly for her husband's boat, but there was nothing she could do to warn either of the men. At about the same instant that the two boats collided, she had to swerve out of the way so that the skier wouldn't run into her boat.

The johnboat operator didn't see the runabout coming because his back was facing in the direction from which the runabout was coming. Fortunately, it hit the johnboat with a glancing blow and only caved in the side of the johnboat. The two boats then separated and headed in different directions. The johnboat operator was thrown out of the boat. The boat continued on under power with a hysterical four year old girl still sitting on the floor in 6 to 8 inches of water.

It proceeded generally in a straight line for somewhat over 50 yards. At that point, the outboard motor turned and the boat began to travel in fairly tight circles. The operator swam to the area that the boat was in and attempted to grab hold of the gunwale as the boat went by. His intention was to allow himself to be dragged by the boat while he reached for and depressed the stop button on the front of the engine. He missed on his first attempt. When the boat came around again, he grabbed the gunwale and his legs were pulled under the boat. He felt the wash of the propeller as it passed close to his feet. He let go. His third attempt was successful. He grabbed the gunwale and made a lunge for the stop button. As he depressed it, he realized that much of his body weight was on the transom corner. The combination of body weight and rapid deceleration capsized the boat.

The child was thrown clear of the boat and floated safely in her life vest. Her father went to her and comforted her while her mother motored over. The child and her father boarded the johnboat and all went to shore.

The overturned johnboat was hauled to shore and righted. The hittor arrived on the scene and identifications, etc., were exchanged. The damaged side of the johnboat was straightened

somewhat and the owner pulled the spark plugs on the soggy outboard and dewatered it. The plugs were reinstalled and the engine was started.

The wife and two children returned to the launch site in the wide johnboat and the husband followed in the damaged boat. No one had been injured.

4.0 FACTS FROM THE BOAT INSPECTION

The 12' 1" johnboat was about four years old and weighed approximately 70 lbs. It had a gunwale beam of 43", a chine beam of 30-1/2", and a 15" transom. It was powered by a 1972 ten horsepower outboard motor. The boat had had hard use and showed it. The owner had added navigation lights and some tubes in the floor area aft designed to provide some added stiffness (see photos). The aluminum bent upon impact, but didn't rupture. In fact, the boat didn't leak after the accident.

There was very little damage to the 1973 fiberglass runabout. It had a 14' 2" long semi-v hull with a 70" beam, weighed 500 lbs, and had a maximum horsepower capacity of fifty. It was powered with an 85 horsepower outboard. Damage included some minor scrapes and gelcoat chips on the forward port chine (see photo).

5.0 PSYCHOLOGICAL AND HUMAN FACTORS

Of course, the operator of the runabout should have had an observer with him while pulling a skier, but he didn't. In that case, he should have been very careful to keep a watchful eye both in front of him and on his skier. As he rounded the island, he must have been looking aft for quite a number of seconds because he never saw the two johnboats. His skier must not have realized that the boat was going to collide with the johnboat since he didn't attempt to warn the driver of the impending collision.

The possibility exists that the operator of the runabout wasn't looking at the skier at all, but was focusing his attention on something or someone on the island. At any rate, he was inattentive and negligent of his watchkeeping duties. It is difficult to determine what type of action would best reduce the number of collisions due to an inattentive driver. Perhaps

an ad campaign showing the results of inattentive boat operation would help to reduce the rate of this type of accident. However, it is quite probable that any type of education campaign would not have had an effect on this particular driver. During the telephone interview, he complained bitterly at the fact that little boats were allowed to boat on the lake. He felt that johnboats should not be allowed to traverse any waterway larger than a pond or creek. He didn't think he was in the wrong for hitting the johnboat and became quite defensive as the conversation went along.

6.0 PROBABLE CAUSE OF ACCIDENT

The operator of the runabout was inattentive. He was looking aft as he rounded the island and never saw the two johnboats. The noise of his motor prevented him from hearing them.

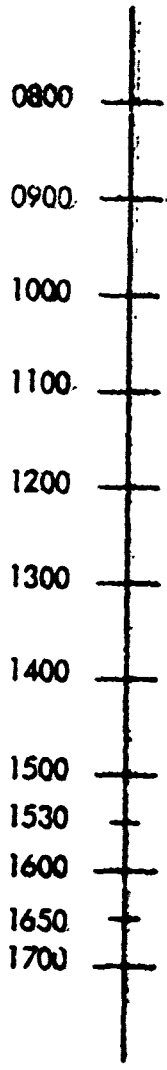
7.0 DYNAMICS/ANALYSIS OF ACCIDENT

The runabout hit the johnboat on the starboard side and caused the starboard gunwale to submerge for a short length of time. The forward port corner of the tri-hulled runabout probably continued over the top of the bow of the johnboat and held the gunwale under for a period long enough for 6 to 8 inches of water to enter the johnboat.

The child was sitting on the floor, aft, and stayed with the boat; however, the impact knocked the operator out of the boat.

Six inches of water in the boat weighed about 780 lbs, thus the boat slowed down quite a bit after the collision. The torque on the outboard probably slowly turned the motor until it reached its limit. The added drag due to the sharp turn input slowed the boat even more so that it was possible for the owner to grab the gunwale and turn off the engine.

TABLE I. THE LINE OF EVENTS IN THE ACCIDENT



0800	Hittee arose
0900	Hittee went shopping with family
1000	
1100	Hittee ate lunch
1200	
1300	Hittee launched boats
1400	Hittee and family picnicked
1500	Hittee left picnic site for launch ramp
1530	Collision occurred
1600	Hittee dewatered outboard and straightened out boat
1650	Hittee took boats to launch ramp
1700	

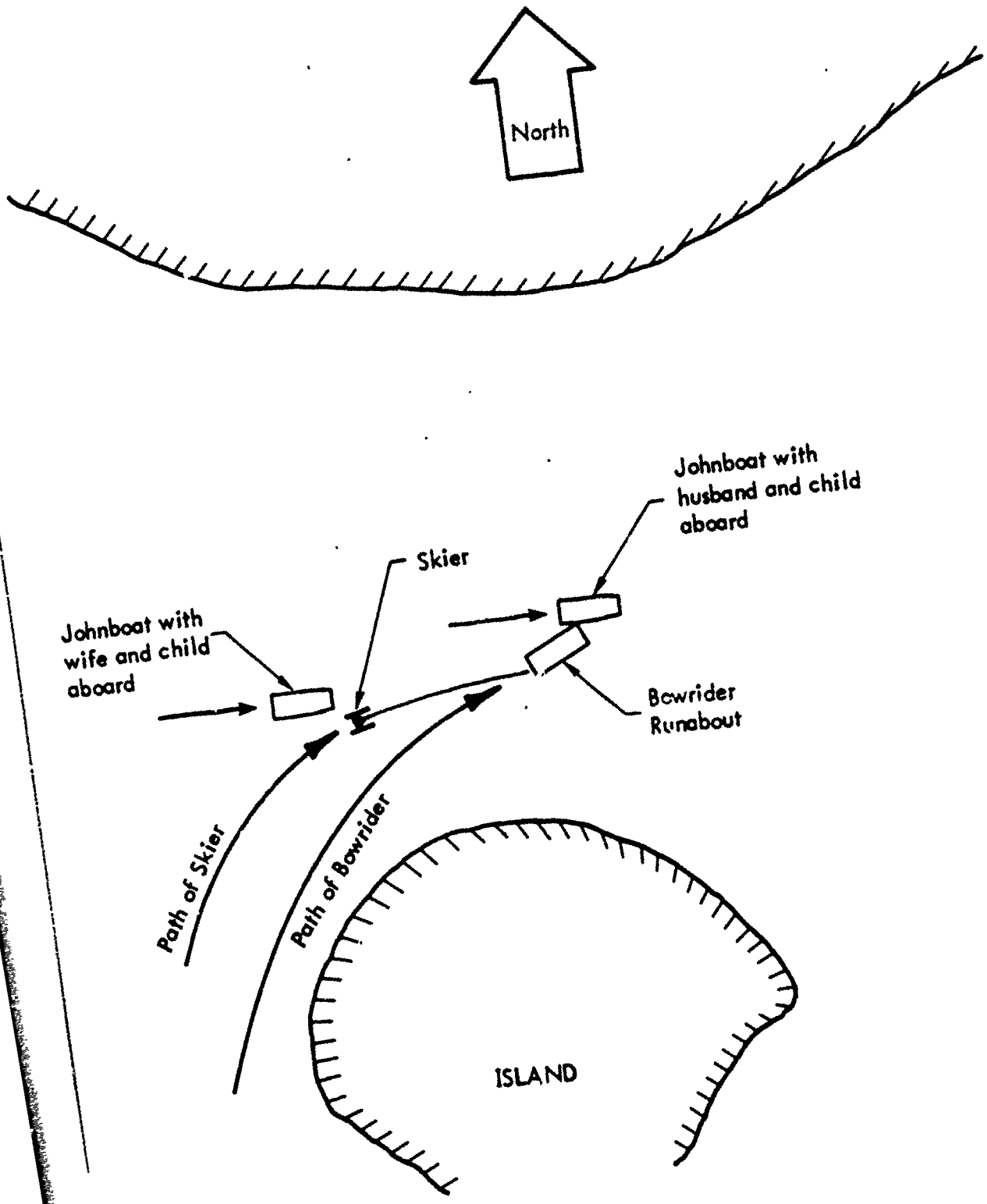


Figure 1. Collision Area Diagram

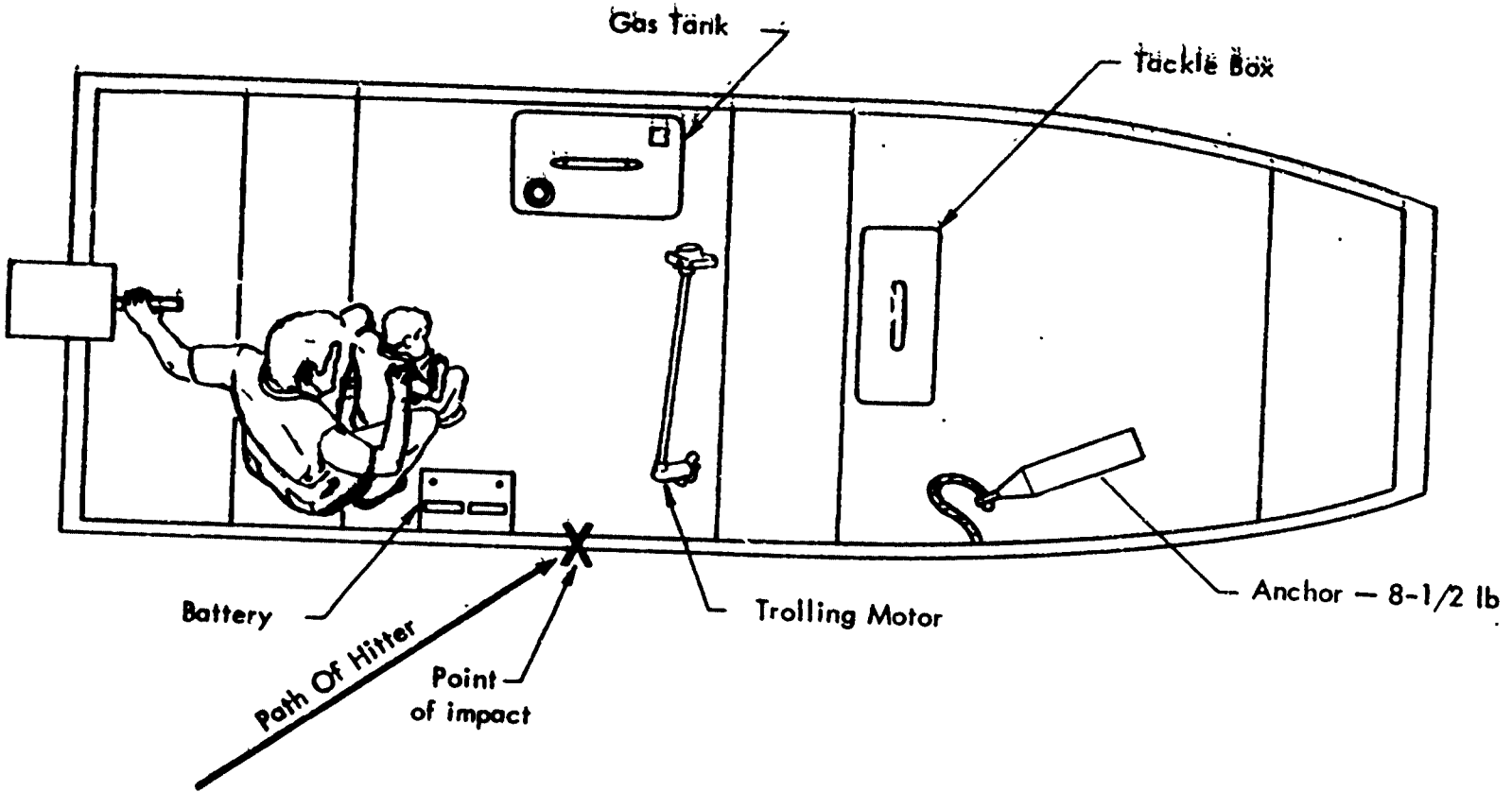


Figure 2. Plan Of Hittee

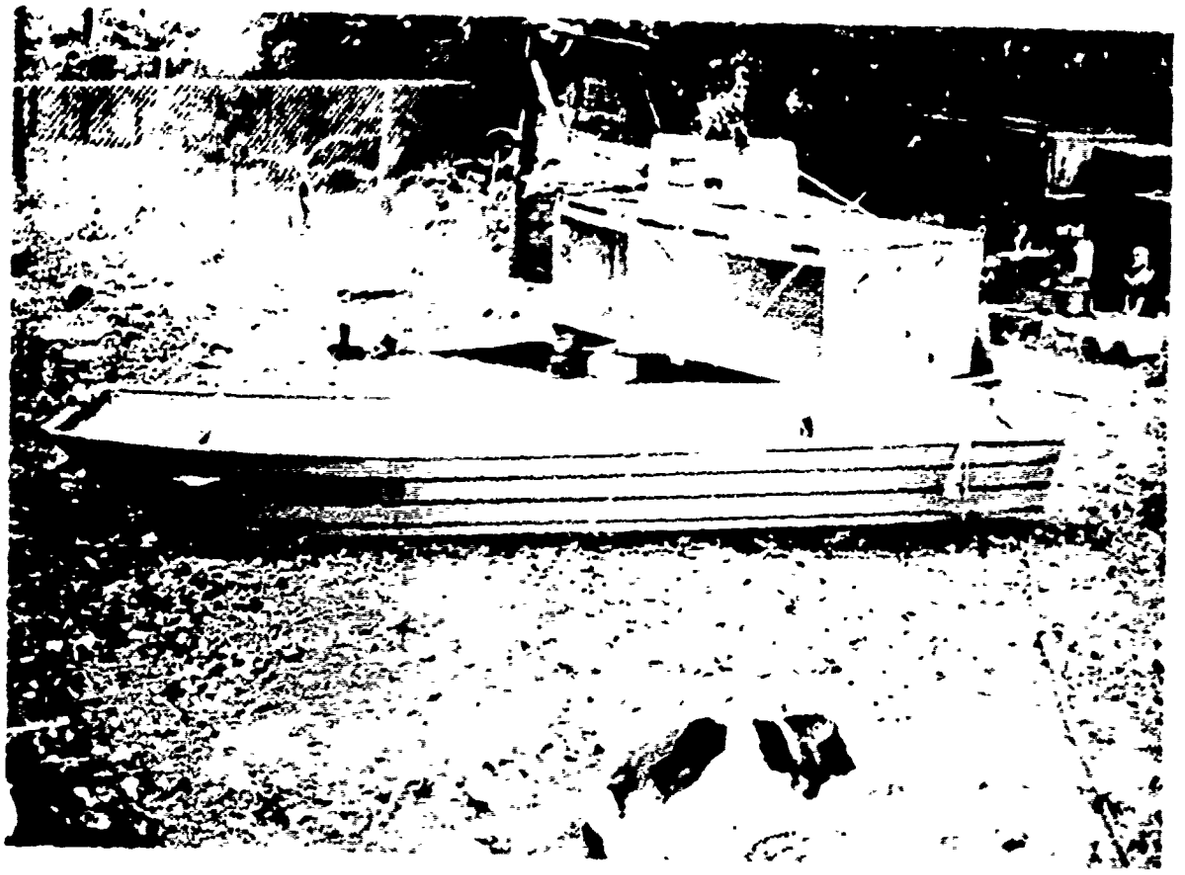


Figure 3. Johnboat - Profile

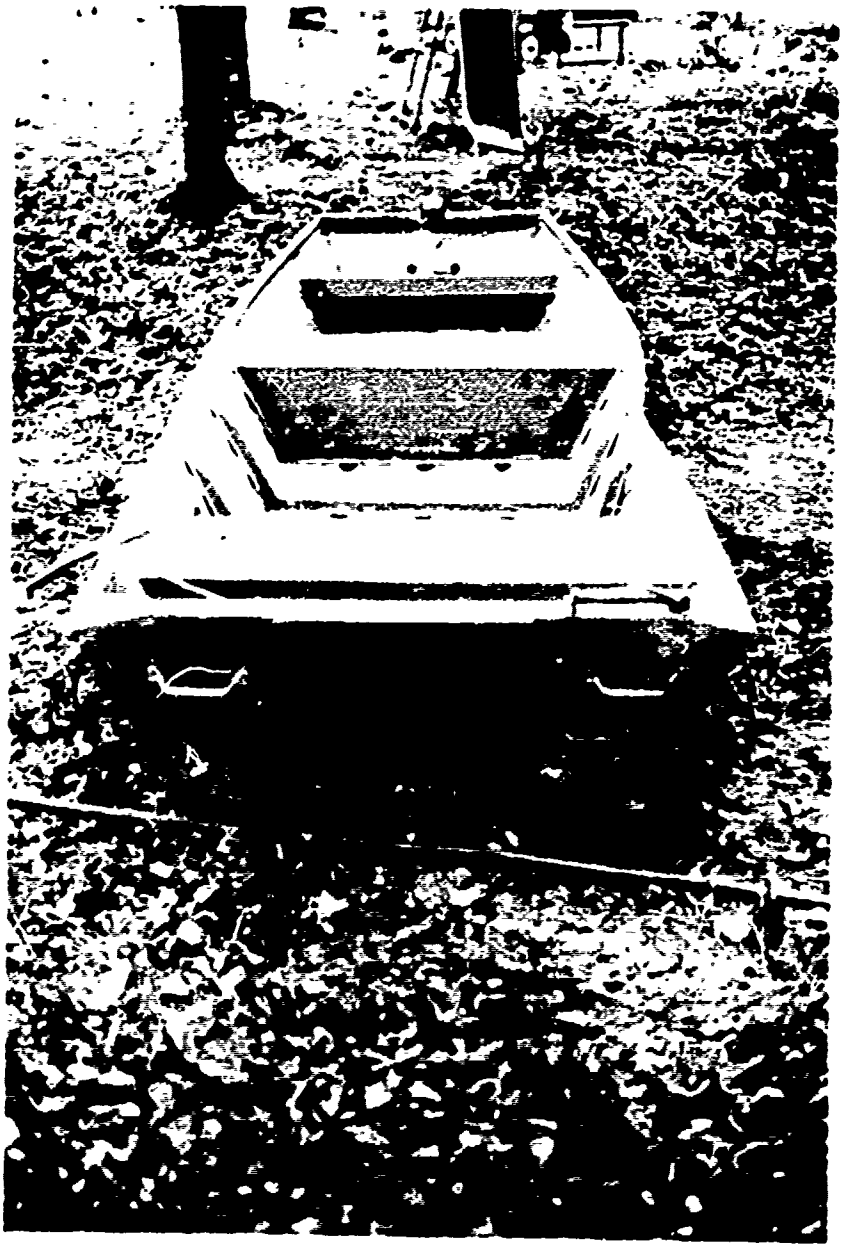


Figure 4. Johnboat - View From Stern